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ABSTRACT

Relationships between student characteristics (academic as well as personal) and student changes were investigated. Student changes were measured by growth scores with the following four criterion measures: Test on Understanding Science; Watson-Glaser Critical Thinking Appraisal; A Scale to Measure Attitude Towards Any School Subject; and Student Perception of Teacher Style. The sample used in this study consisted of 471 undergraduates enrolled during the 1971-1972 academic year in the course called "Thought and Structure in Physical Science" at the University of Illinois. Twenty-six independent predictors were selected. High school and college backgrounds in science and mathematics as well as subscores on selected parts of ACT were included among the academic predictors. Dogmatism, flexibility, tolerance, responsibility, and intellectual efficiency were among the predictors identified as personal factors. The collected data were treated using analysis of variance, analysis of covariance, and multiple regression techniques. Among the findings were that consideration of the personal and instructor variables significantly increased the ability to predict student changes and that it was apparent that there were abilities which were significant in predicting student changes other than those measured by standard achievement and intelligence tests. (Author/MLH)

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Final Report

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Grant No. OFG-7-72-0024 (509)

IDENTIFICATION OF POSSIBLE VARIABLES FOR PREDICTING STUDENT SUCCESS IN PHYSICAL SCIENCE COURSES DESIGNED FOR NON-SCIENCE MAJORS.

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IDENTIFICATION OF POSSIBLE VARIABLES FOR PREDICTING STUDENT CHANGES IN A PHYSICAL SCIENCE COURSE DESIGNED FOR NONSCIENCE MAJORS

by

Makram I. Himaya

An Abstract

Of a thesis submitted in partial fulfillment of the
requirements for the degree of Doctor of Philosophy
in Science Education, College of Education,
in the Graduate College of
The University of Iowa

December, 1972

Thesis supervisor: Professor Robert E. Yager

ABSTRACT

Relationships between student characteristics (academic as well as personal) and student changes are investigated. Student changes are measured by growth scores with the following four criterion measures:

1. Test on Understanding Science (TOUS)
2. Watson-Glaser Critical Thinking Appraisal (WGCTA)
3. A Scale to Measure Attitude Towards Any School Subject (Silance)
4. Student Perception of Teacher Style (SPOTS)

The sample used in this study consisted of undergraduates enrolled during the 1971-1972 academic year in the course called "Thought and Structure in Physical Science" at the University of Illinois. The course is an elective and can be used to satisfy the general education requirements for graduation. Twenty-six independent predictors were selected. High school and college backgrounds in science and mathematics as well as subscores on selected parts of ACT were included among the academic predictors. Dogmatism, flexibility, tolerance, responsibility, and intellectual efficiency were among the predictors identified as personal factors.

Analyses (at 0.05 level) for pretest and posttest measures of student changes permit the following statements:

1. There are significant increases in student understanding of science and the scientific process.
2. There is a significant increase in positive student attitude toward open instructional climate.
3. There is no significant growth in positive student attitude toward the physical science course.
4. There is a significant decrease in student critical thinking ability.

The following statements concerning prediction can be made:

1. The set of all twenty-six predictors (academic, instructors, and personal) accounted for 15.42%, 18.42%, 11.83%, and 22.00% of the variance in predicting the growth scores on TOUS, WGCTA, Silance, and SATIC respectively. When each of these totals is arbitrarily assumed to be 100%, the following statements can be made regarding the contributions to the variance for the three types of predictors:
    a. The academic factors accounted for 35.58%, 57.28%, 57.82%, and 24.41%.

b. The effect related to various instructors accounted for 38.93%, 6.46%, 18.25%, and 49.18%.

c. The personal factors accounted for 25.49%, 36.26%, 23.93%, and 26.41%.

2. Since the consideration of the personal and instructor variables significantly increased the ability to predict student changes it is apparent that there are abilities which are significant in predicting student changes other than those measured by standardized achievement and intelligence tests.
3. Scores on intellectual efficiency subtest of CPI and whether the course was taken to meet a requirement or as a free elective were the best predictors for TOUS and Silance.
4. While completing a previous course in college physical science was the best predictor for WGCTA and SATIC, it did not serve as a suitable predictor for Silance.
5. Sex, mathematics scores on ACT, and scores on achievement via conformity subtest of CPI were the least effective predictors for growth scores on TOUS, WGCTA, and SATIC.
6. Completion of high school courses in sciences and mathematics; completion of courses in college

biology and mathematics; and English, science, and mathematics scores on ACT were found to be insignificant predictors for student change.

7. Personal predictors - namely, intellectual efficiency for predicting growth scores on TOUS; tolerance and responsibility for predicting growth scores on WGCTA; dogmatism, flexibility, and achievement via conformity for predicting growth scores on SPOTS - were among the significant predictors.

The results concerning the effect of personal variables on student change reveal that:

1. There is a significant difference between the open and the closed-minded groups with regard to growth on understanding the nature of science (as measured by TOUS). The open-minded group showed significantly greater growth.
2. Students taking the course as an elective score significantly higher on WGCTA and Silance tests than students taking the course to meet a requirement.

Abstract approved: Robert E. Yager, Thesis supervisor
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9-13-72 date

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LIST OF ABBREVIATIONS

$\bar{Y}$(adj.)	Adjusted mean score on posttest
ACT	American College Testing
ACE	American Council on Education
BSCS	Biological Science Curriculum Study
CBA	Chemical Bond Approach
CPI	California Psychological Inventory
CHEM STUDY	Chemical Education Material Study
CCTT	Cornell Critical Thinking Test
CT	Critical Thinking
DF	Degrees of Freedom
DS	Dogmatism Scale
ESCP	Earth Science Curriculum Project
ETS	Education Testing Service
F	F Ratio
GPA	Grade Point Average
HOSS	History of Science Scale
HPP	Harvard Project Physics
HS	High School
L	Level of significance
$\bar{X}$	Mean score on pretest
$\bar{Y}$	Mean score on posttest
MS	Mean sum of squares
N	Number of students in a Sample

LIST OF ABBREVIATIONS CONTINUED

n	Number of students in a subclass
NOSS	Nature of Science Scale
X	Pretest score
Y	Posttest score
PSSC	Physical Science Study Committee
SD	Standard Deviation
Silance	Scale to Measure Attitude Towards Any School Subject
SPOTS	Student perception of Teacher Style
SRA	Stepwise Regressional Analysis
SS	Sum of the Squares
TPCT	Test on Principles of Critical Thinking
TOUS	Test on Understanding Science
T	T statistic
WGCTA	Watson-Glaser Critical Thinking Appraisal

DEFINITION OF TERMS

Advanced Student. A student will be identified as an advanced student if he is listed on the roster as a junior or as a senior.

Beginning Student. A student will be identified as a beginning student if he is listed on the roster as a freshman or sophomore.

American College Testing. The results of the battery of tests given to high school seniors prior to entrance in college are reported as four sub-scores and a composite score. The four sub-scores are English, Mathematics, Social Science, and Natural Science.

Criterion Variable. This refers to the dependent variable. For the purpose of this study there are four criterion variables. These are: 1. Test on Understanding Science (TOUS), 2. Watson-Glaser Critical Thinking Appraisal (WGCTA), 3. A Scale to Measure Attitude Towards Any School Subject Matter (Silance), 4. Student Perception of Teacher Style (SPOTS).

Independent Variables. These are the variables which are used to predict a numerical value for the dependent variable. These variables are not necessarily independent in the sense that they do not have any correlation with any of the other independent variables. Twenty-six independent variables were used in the present study.

Open and Closed System. If a person strongly agrees with statements on the Dogmatism Scale, then he possesses a closed belief system which is one extreme of the particular characteristic being considered. On the other hand, if the person strongly disagrees with statements on the Dogmatism Scale, then he possesses an open belief system. This is the opposite extreme of the particular characteristic being considered.

Student Changes. Observable differences in students between initial enrollment in a course (in this study the "Science Thought" course taught at the University of Illinois) and completion of the course. In some instances the term is used synonymously with the term instructional outcomes. The latter term may erroneously imply a cause and effect relationship between course instruction and observable changes in students.

CHAPTER 1

INTRODUCTION

A. Rationale and Introduction To The Problem

Despite the critical importance of personal characteristics of students, very little is known about the relationship between student personality and instructional outcomes. The literature reveals numerous studies concerning relationships between various aspects of the academic backgrounds of students and their achievement. However, using student academic factors as the sole predictor of students' learning is questionable as well as unwarranted. Student learning cannot be attributed to academic factors only; it probably involves the interaction of several different factors including the personal characteristics of the student himself. Poor performance by students may be caused not only by deficiency in the cognitive domain but also by factors in the affective domain. One clue comes from Postman (1948) who concluded that the individual establishes perceptual defenses against inimical stimuli.

By evaluating student characteristics it may be possible to teach those students who are enrolled in a given course rather than the students whom teachers would prefer to have enrolled. This would also serve to maximize the achievements of which the students are capable.

In a recent address at the annual conference of the Association for Supervision and Curriculum Development, Bruner (1971) revised his ideas, which were published in The Process of Education. Bruner stated:

> I would be quite satisfied to declare, if not a moratorium, then something to deemphasize the structure of discipline and deal with it rather in the context of the problems that face us.... The issues facing us in the seventies would have to do with how one activates to tempt one to want to learn again. What is important is to learn to bring all one's resources to bear on something that matters to the student now (p. 20).

One solution in implementing Bruner's suggestion is to view learning as a kind of internalization. Internalization (Kelman, 1961) can be said to occur when a student accepts an idea because it is congruent with his established value systems or because it is inherently conducive to the maximization of his values. Decreasing enrollments in high school and college science courses, as well as the current public distrust of scientists and the unwillingness of people to support basic research, are examples of the negative impact of science teaching. The social, cultural, and economic conditions which gave rise to the government-sponsored curriculum projects in science of the 1960's are not, however, those of the 1970's. Therefore, science eudcators must respond to the demand of adding other dimensions when defining, evaluating, and predicting instructional outcomes. These dimensions should take into account additional factors including the personal characteristics of the student himself.

If one sees little or no value (or relevance) in the process of science, he is unlikely to devote the necessary time and energy required to benefit from science courses. For courses to be effective and to achieve their desired goals, they need to be based on established knowledge of student attitudes, that is, of their concepts and perceptions concerning science and scientists. This knowledge should be the point of departure for any change desired in student concepts, attitudes, and behavior.

What behavior pattern might we expect from students with different personal characteristics? A logical and psychological analysis of the traits and value systems of individual students is needed. These student traits could then be used to predict consequent learning and attitudes. To some extent, this is suggesting that the personality characteristics of students should be studied as to their effect on instructional outcomes. It can also be hypothesized that student personalities contribute significantly in predicting student learning and attitudes towards such learning.

It can therefore be hypothesized that students with different personality characteristics think and function differently. They are seeking to satisfy different needs. Their perceptions of the same tasks, their attitudes towards them, and their consequent performances can be expected to differ widely. It is reasonable to expect that some tasks would be met with enthusiasm by students with open minds, while these same tasks would be more difficult if performed by the students with closed minds, and vice versa.

Science educators should be interested in the following questions: If an understanding of the nature of science, an ability to think critically, and the development of positive attitudes are highly correlated to open-mindedness, then what factors should influence sectioning of students? How does such correlation affect education materials? What materials are not appropriate for a given student? How and to what extent does the open- or closed-mindedness of the individual influence his role perceptions in learning?

As the focus shifts to student characteristics, research designs should employ variables regarding teaching methods and dimensions of individual differences bearing some theoretical relationship to one another, as suggested by Cronbach (1957). A more specific theory about the conditions which affect learning for students of high and low dogmatism would be desirable if dogmatism is to be investigated as a student characteristic affecting learning.

The main objective of this study was to investigate relationships between student characteristics (academic as well as personal) and student changes. Student changes are measured by the growth scores in the areas of understanding the nature of science, critical thinking, attitude toward the physical science course, and attitude toward instructional climate as measured by *Test on Understanding Science*, *Watson-Glaser Critical Thinking Appraisal*, *A Scale to Measure Attitude Towards Any School Subject*, and *Student Perception of Teacher Style* respectively. The research is guided by the hypothesis that students' responses to statements on attitude scales for measuring dogmatism and the nine scales of *CPI* correlate with student responses on the criterion measures.

The sample used in this study consists of students enrolled in the course called "Thought and Structure in Physical Science" at the Urbana campus of the University of Illinois. A brief description of the objectives and philosophy of the course is included in Appendix B.

B. Statement of Research Hypotheses

The following four dependent variables and twenty-six independent variables were selected for this study:

Dependent Variables

1. Scores on the Test on Understanding Science(TOUS)
2. Scores on the Watson-Glaser Critical Thinking Appraisal (WGCTA)
3. Scores on A Scale to Measure Attitude Toward Any School Subject (Silance)
4. Scores on Student Perception of Teacher Style (SPOTS)

Independent Variables

Academic and Identification factors

1. High school rank
2. College physical science hours
3. High school physical science units
4. College mathematics hours
5. High school mathematics units
6. Natural science score on ACT
7. Mathematics score on ACT
8. Student classification (F & S; J & S)
9. Course taken as a requirement or as an elective
10. College biological science hours
11. High school biological science units
12. English score on ACT
13. Sex
14. Instructor #1
15. Instructor #2

16. Instructor #3

Personal Characteristics:

17. Dogmatism (D)
18. Flexibility (Fx)
19. Tolerance (To)
20. Achievement via independence (Ai)
21. Intellectual efficiency (Ie)
22. Achievement via conformity (Ac)
23. Responsibility (R)
24. Self acceptance (Sa)
25. Social presence (Sp)
26. Capacity for status (Cs)

The purposes of this study were as follows:

1. To test (at the five percent level) whether the pretest-posttest mean scores on all parts of each of the four criterion variables are significantly different. Specifically, the following hypotheses, stated in the null form, were investigated:
    a. There was no significant growth in student ability to understand science as measured by TOUS (Subscore I)
    b. There was no significant growth in student ability to understand scientists as measured by TOUS (Subscore II)
    c. There was no significant growth in student

ability to understand the scientific process as measured by TOUS (Subscore III)

d. There was no significant growth in student ability to draw valid inferences as measured by WGCTA (Subscore I)

e. There was no significant growth in student abiliby to recognize assumptions as measured by WGCTA (Subscore II)

f. There was no significant growth in student ability to reason deductively as measured by WGCTA (Subscore III)

g. There was no significant growth in student ability to interpret results as measured by WGCTA (Subscore IV)

h. There was no significant growth in student ability to evaluate arguments as measured by WGCTA (Subscore V)

i. There was no significant change toward more favorable attitude toward the course in physical science as measured by Silance

j. There was no significant change toward more favorable student attitude toward open instructional climate as measured by SPOTS.

2. To determine the degree of relationship of each of the twenty-six independent variables to each of the four criterion measures.

3. To determine the order of importance of the significant independent variables for each of the four dependent variables.
4. To find what increase in predictive accuracy is attained, by combining measures of personal and instructor variables with measures of the thirteen academic conventional predictors in the prediction of student performance on each of the four criterion variables.
5. To test the null hypotheses that there are no differences among the adjusted means on the four criterion measures (adjusted for pretest differences) for the following subpopulations:
    a. Students who are in the highest third versus those in the lowest third on the dogmatism variable.
    b. Students who are in the highest third versus those in the lowest third on the flexibility measure.
    c. Students taking the course as a free elective versus those taking the course as a requirement.
    d. Students classified as beginning students versus students classified as advanced students.

e. Students who have enrolled with each of the three instructors.

f. Male students versus female students.

CHAPTER II

REVIEW OF LITERATURE

A. Literature Related of Student Changes

Understanding the Nature of Science

The National Society for the Study of Education, in its fifty-ninth yearbook, listed the development of understanding of science and scientists as a main objective of science teaching. The development of the nature of science has been described by Kimball (1967-1968) as "one of the most commonly stated objectives for science education," and by Saunders (1955) as "probably the most important purpose of science teaching." Rogers (1960) states that the non-scientist needs a "healthy understanding of the nature of science."

Concern for this objective has been evidenced not only in the United States but also in many other countries. In 1964, the American Association for the Advancement of Science established a Commission on Science Education with the stated purpose "to foster, in every way possible, scientific literacy among the American people."

In England, the policy statement of the Association of Science Education on science and education (1963) stressed the importance of developing an understanding of the nature of science among school pupils.

This widespread concern of science educators with the development of student understanding of the nature of science is reflected in the statement by Robinson (1968) that "the challenge to science education is to bring to the full range of young people a comprehension of the nature of science as a humanistic enterprise." A considerable amount of time and effort has been expended in research on the development of techniques of teaching scientific facts and generalizations and the ability to deal with these facts, but, as Tisher (1967) pointed out, "little effort, by comparison, has been expended to determine the degree to which, and the processes whereby, students develop an understanding about science."

One does not have to read extensively in the literature relating to understanding science and scientists before he finds considerable ambiguity surrounding the subject. First, there is uncertainty about the extent of the illiteracy concerning science and scientists; and secondly, uncertainty about what can or should be done about it. Some polls and surveys of opinion (Allen, 1959; Barker, 1956; Mead, 1957; Remmers, 1957; Wilson, 1954) have indicated that high school students have misconceptions about science, including disparaging stereotypes of scientists. Allen, studying New Jersey high school seniors, observed a more favorable attitude toward the scientific enterprise than other investigators. The surveys, with the exception of Kimball's (1967-1968), generally indicate no significant differences between the science and non-science groups. These surveys also show that the higher the intelligence, the greater the likelihood of constructive attitudes toward the scientific enterprise and the fewer stereotypes of scientists. Among non-science college students, Mitias (1970) found no dominating stereotype or concept of science, but over seventy percent of the concepts and opinions about science and scientists were negative or neutral in character. It is not inappropriate to generalize these findings to the larger American society and conclude that most Americans have little knowledge about the nature of science, that their attitudes toward the scientific enterprise and scientists are at best neutral, and that many negative concepts and attitudes persist.

The number of measuring instruments that test for understanding science and scientists is small - TOUS, FAS, NOSS, WISP, and SPI. These tests have been compiled after consultation with numerous science researchers and educators.

TOUS was originally designed for testing high school students, yet it is often used for testing college students and science teachers (Jerkins, 1969; Jones, 1969; Miller, 1963; Olstad, 1970; Schmidt, 1967-1968; Welch and Walberg, 1967). One suspects that TOUS was used because of its availability and the lack of other instruments rather than because of its suitability. Whether or not TOUS is suitable for testing college students, teachers, and scientists has not been considered. An important consequence of having only a few measuring instruments from which a researcher can choose is that research designs tend to be based on the instruments available. TOUS has been revised for use by junior high students (Jerkins, 1969), and other modifications have been made by individual investigators.

Since some evidence now points to only a slow, imperfect attainment of understanding of science and scientists within the usual science course work, several persons and schools have inaugurated courses specifically designed to deal with the aims and methods of science, the nature of science, the character of the scientific enterprise and the scientist, and the interrelationship of science and culture (Cossman, 1967; Carey & Strauss, 1968; Jones, 1969). In all the cases where testing was included in the experiment, significant increases in the understanding of science and scientists were found. It is interesting to note that Jones (1969) found that the experimental group consisting of eighty-seven non-science majors at the University of Tulsa, who were taking a general education physical science course, had significantly higher adjusted mean posttest scores on TOUS than the control group consisting of fifty-five science majors. In addition to facts and principles, the general education physical science course was also concerned with the historical development and the philosophy of science and the interaction of science and society.

The findings of MacKay (1971) suggest that time and effort could be profitably expended in developing teaching materials to improve student understanding of the nature of science. Until such a time as these materials exist, this important objective of science teaching will largely fail to be achieved. A few universities are beginning to establish history and philosophy of science courses for prospective science teachers and scientists in an attempt to attain this objective. Such an approach appears to be the most direct way of developing an understanding of science and scientists.

The following paragraphs outline a sample of the studies which attempt to measure the understanding of science as one of the outcomes of a particular course. TOUS was the most common instrument used.

A study (Crumb, 1965) on the understanding of science by 1,705 high school physics students showed no significant gain in understanding science among students studying high school physics. It also showed no significant difference between those students studying one or two semesters of traditional physics. Crumb reported that the magnitude of gain was sensitive to the teaching method used in the course.

Kimball (1966) measured changes in the opinions of high school physics students concerning the nature of science during the course of a school year in which they studied Harvard Project Physics. These students showed a significantly improved understanding of the nature of science.

Not all of the studies concerned with curriculum materials and the nature of science have yielded positive results. The results of an analysis of covariance (Trent, 1965), when the TOUS pretest scores were controlled, showed no significant difference in the understanding of science gained by students studying PSSC physics and those in courses using traditional kinds of materials.

The negative results reported (Crumb, 1965; Trent, 1965) leave the question of the effect of PSSC materials on increasing the understanding of the nature of science in doubt while raising some new questions. Are there definite regional differences in the levels of understanding science by physics students, as measured by the criterion instruments? Does PSSC physics cause a uniform growth in understanding science, given different initial levels of understanding? What part do the teacher's background, personality, and attitude play in relation to tests on understanding science when different curriculum materials are used? This last question is particularly relevant when recent findings (Rothman, 1969; Rothman, Walberg, & Welch, 1969) are considered. Among other things, they found correlations between personality traits and attitudes of certain physics teachers and their students' understanding of science and scientists. Rothman (1969) found a significant correlation between the backgrounds and experience of physics teachers and student scores on TOUS. However, he found no significant relationship between the TOUS scores of teachers and physics achievement of their students.

Carey and Strauss (1970) showed that little if any relationship exists between an understanding of science and academic variables such as high school and college background in science, mathematics, and grade point average. Likewise, no correlation was found between scores on the Wisconsin Inventory of Science Processes (WISP) instrument and scores on science teaching experience. The population for the study consisted of thirty-one teachers in a graduate level course in science education at the University of Georgia in 1968-1969.

Further verifications of specific studies have been conducted to ascertain what differences in the understanding of science and scientists exist between groups with different amounts of science education and experience (Carey and Strauss, 1968, 1970; Jerkins, 1969; Kimball, 1967-1968).

From these studies the following can be concluded: (a) the common assumption that understanding about the nature of science, the scientific enterprise, and scientists occurs via a kind of osmotic process through science courses and work experience needs to be seriously questioned; (b) according to the findings by Kimball (1967-1968), one's view of science is fairly well-established by the time of graduation from college and does not change much after that; (c) one's position as a science teacher or scientist does not insure a thorough understanding of the nature of science. It cannot be stated that standard science course work does not increase the understanding of science, since some studies (Jones, 1969) showed higher TOUS scores among science majors than non-science majors. But it is apparent (Carey & Strauss, 1970; Jerkins, 1969; Welch, 1967-1968) that the gains in understanding about science are not uniformly related to course work or to teaching experience.

Critical Thinking

Although the need for critical thinking is recognized, there is wide divergence on what is meant by the term. Dressel and Mayhew (1954) refer to five abilities which constitute critical thinking: (a) the ability to define a problem; (b) the ability to select information pertinent to the solution of a problem; (c) the ability to recognize stated and unstated assumptions; (d) the ability to formulate and select relevant and promising hypotheses; and (e) the ability to draw valid conclusions and to judge the validity of inferences. A group concerned with the improvement of critical thinking suggests that more attention be given to helping students "develop problem-solving methods which will yield more complete and adequate solutions in a wide range of problem situations." (Bloom, 1956)

Because of the rapid changes in America's society and the proliferation of new knowledge taking place today, individuals have a greater need for critical thinking ability than ever before in history. In America, people are asked to make decisions concerning difficult and complex social issues and the ability to think critically is often needed to provide the best basis for making such decisions. America's destiny may be affected by the ability of our teachers and schools to develop students who are able to think critically. Perhaps Carlos de Zafra (1966, p. 231) best described the importance of critical thinking ability when he wrote the following:

> For the first time in his long history, mankind has in his power the ability to fill his cornucopia or to destroy himself. Because the rate of change has greatly accelerated and because the applications that are made of mankind's discoveries and inventions are more important than are the discoveries and inventions themselves, mankind now needs to do some critical thinking of an unprecedented quality. The future of the human race depends upon the quality of critical thinking that is done in the world today.

Dressel and Mayhew (1954, pp. 25-36) recognized the important role that critical thinking plays in citizenship when they wrote:

> The essence of the democratic creed is that each person possesses potentialities for discovering his own problems and for developing personally satisfactory and socially acceptable

> solutions to them, so that he has no need to defer completely to the will of an authority, although he is perfectly willing to make use of expert opinion when relevant.

Much has been written concerning the importance of developing skill in critical thinking. Apparently everyone agrees that teachers should devote a considerable amount of time to developing such skill. Unfortunately, though, many investigators have found that the schools are not developing skills in critical thinking as they should. It seems possible that one of the major reasons why some of the procedures designed to develop skill in critical thinking are not being used is that they are extremely difficult to use. If the school is going to be concerned with improving critical thinking, teachers and administrators should be involved not only in problems of content and methodology, but also in problems of measurement of progress towards these goals. Several studies (among them, Dressel & Mayhew, 1954; Houle, 1943) support the position that institutions with a greater degree of student self-determination, flexibility of curriculum, and freedom from authoritarian control of behavior have a significantly better record in increasing critical thinking.

Several persons and schools have inaugurated courses specifically designed to deal more directly in "teaching" critical thinking. In some cases this may amount to actual instruction in the rules of logic and their application. Such studies have produced conflicting findings. Henderson (1958) reports that the experimental students who were tutored in the principles of logic and given practice in their use, showed greater gains on measures of critical thinking than did their controls. Dressel and Mayhew (1954), on the other hand, report that institutions having a special course in critical thinking do not stand apart from those which do not have such courses. According to Dressel and Mayhew (1960) evidence favors direct teaching over indirect teaching of scientific methods and attitudes.

The number of measuring instruments that test for critical thinking is small - WGCTA, ACE, TPCT, CCTT. The Watson-Glaser Critical Thinking Appraisal (WGCTA) has been widely used. The items on this instrument are not specifically limited to science; and, as a result, any change in scores may be attributed to other disciplines. Because of this, any difference between group scores can be attributed to a particular instructional procedure in science if the experimental and control groups have identical teachers and types of courses in all other subjects. Yager (1966) supported the idea that there are other factors influencing the development of critical thinking besides the course being taught. He used the BSCS Blue Version in his study and indicated that the teacher does affect the development of critical thinking skills in students.

An increasingly important concern of science educators is whether or not new curriculum materials, such as PSSC, BSCS, HPP, and ESCP materials, directly enhance the ability to think critically. The relevant literature contains a number of reports on critical thinking. The following paragraphs present a small but representative sample of the studies which attempted to measure critical thinking as one of the outcomes of a particular curriculum and/or course. The WGCTA test was the most common instrument used in research studies.

Several studies (Crumb, 1965; Heath, 1964; Troxel, 1968) have considered the effect of PSSC, CHEM Study, and CBA courses on critical thinking skills. The results of these studies indicate that these course experiences enhance the critical thinking ability of students more than traditional courses. Gains in critical thinking in both CBA and CHEM Study were found by Troxel to be superior to those in a traditional course; and, for able students, CBA was superior to CHEM Study.

Henkel (1967-1968) investigated the effects that the instruction in two undergraduate courses in general physics had on the critical thinking ability of students. The study involved some of the students enrolled in two sophomore level physics courses designed respectively for non-physics majors in teacher education and for students in other science related programs. The experimental group utilized the PSSC curriculum and was taught by discussion methods, with the laboratory experiments designed to emphasize a "discovery" rather than a "verification function." The control groups utilized a more traditional general physics curriculum. The WGCTA test was given to evaluate ability to formulate hypotheses and to draw valid conclusions about non-scientific everyday problems. Henkel showed that instruction in undergraduate general physics has a positive effect upon the critical thinking ability of students and that this effect has little correlation with physics aptitude and physics achievement. The increase in critical thinking ability in a group of students utilizing the PSSC curriculum was statistically significant. In general, students with prior physics training showed a significantly greater growth in critical thinking ability than those students without such prior training.

Finally, there was insufficient evidence to determine which teaching methods were superior in enhancing critical thinking.

Rickert (1962) reported that an experimental group of college freshmen in a physical science survey course showed significantly greater gain (at 0.05 level) in critical thinking skills than control groups in the same course and in a traditional physics survey course.

Craven (1966) found that neither critical thinking ability nor the understanding of science were major learning results of college science courses. This conclusion was based on: (a) negative or non-significant correlations between the Cornell Critical Thinking Test (CCTT) and the Test on Understanding Science (TOUS) scores and the total number of science grade points earned by members of each group; (b) lack of a significant difference in critical thinking ability or in understanding of science between science teacher candidates and social science teacher candidates, the latter group having completed half as many credits in science as the former; (c) failure to find a significant difference either in critical thinking ability or understanding of science between high and low sub-groups of science teacher candidates selected on each of the following bases: (a) total number of science grade points earned; (b) the biological-physical science ratio of science credits completed. Craven also found indications that both the science teacher candidates and the non-science oriented groups had misconceptions concerning the nature of science and scientists.

The teacher has been identified by many investigators as a major factor in the development of the critical thinking and creative interests of students in science. Reports by Taylor (1958) summarized the research related to the problem.

The research tends to indicate that if an increased ability to think critically is a desired outcome, then an instructional procedure which is laboratory-centered can be developed to increase this ability. There are many factors operating in the development of critical thinking besides the course outline. Yager (1966) showed that the individual teacher does affect student achievement, including critical thinking, and that different teachers differ in their ability to help students develop critical thinking.

A survey of the literature related to improving critical thinking leads to several general conclusions. The attempts to establish experimentally the psychological nature of thinking have not given conclusive results. Research into effective teaching methods for critical thinking is based almost entirely on pupil activity in problem solving and scientific induction.

Attitudes toward the Course and toward Open Instructional Climate

The ways in which attitudes are developed are many and complex. It is exceedingly difficult to attribute the formation of an attitude to one specific factor because many influences work together. Nor is the development of attitudes merely a result of the maturational process. Attitudes seem to be responses learned as a result of satisfying or frustrating the needs of an individual. "If a person has a satisfying experience, he will develop a favorable attitude toward the situation in which he had that experience. If, on the other hand, he has an unsatisfying experience, his attitude toward the situation involved in that experience will be unfavorable." (Sorenson, 1964, p. 351)

Kelman (1961) proposed a model to conceptualize the processes of attitude formation and attitude change. It starts with the assumption that opinions adopted under different conditions of social influence and, based on different motivations, will differ in terms of their qualitative characteristics and their subsequent histories. Thus, if something is known about the determinants and motivational bases of particular attitudes, predictions about the conditions under which they are likely to be expressed, the conditions under which they are likely to change, and other behavioral consequences to which they are likely to lead can be made. Kelman called these processes compliance, identification, and internalization.

Research on attitude change involves many disciplines and relates to many fundamental questions of human behavior. It is, therefore, not surprising that such research raises many questions which are of fundamental theoretical importance and which also have practical implications.

Festinger's (1957) "theory of cognitive dissonance" is one of the major theories of attitude change. According to this theory, cognitive dissonance is created when a person is confronted with a communication which is at variance with his present attitude. The individual attempts to maintain logical consistency. Comment on this tendency has a long history. For instance, Sumner's (1907) "strain towards consistency"; and Newcomb's (1953) "strain towards symmetry" have influenced much research.

Brehm and Cohen (1959) demonstrated that a chance event may affect the magnitude of dissonance and consequent attitude change, but only under conditions of high choice. Experimentally, these authors found that in a low choice situation, that is, one in which the subject felt he had little alternative but to do what was required of him, no significant attitude change occurred. On the other hand, the attitude of the subject towards the _fait accompli_ became significantly more positive under conditions in which he felt he had a high degree of choice.

The studies summarized below are indicative of the kind of studies that have been made to investigate the attitude changes which may be attributed to school instruction. Coulter (1965) found that inductive methods of teaching produced significantly greater attainment of scientific attitudes and more positive attitudes toward instruction than deductive methods. Sorenson (1966) found that laboratory-centered teaching produced significantly desirable changes in dogmatism tests, while no such changes were found in lecture-demonstration groups. Mahan (1963), using a problem-solving approach, measured a greater growth in personal adjustment and attitude than a traditional approach.

Graig and Holsback (1964) used existing student attitudes in general science to develop other attitudes. Students with low initial interest in a particular area were given supplementary learning experiences using activities they enjoyed. This method raised the interest level of students with few interests, but made little difference to students with an initial wide range of interests.

Even though the number of studies to investigate the attitude changes which may be attributed to school instruction are several times the number reported here, their general nature should now be clear. The above studies are samples indicating possible attitude changes as a result of teaching. The majority of these studies support the belief that attitudes can be changed by teaching. The results suggest that much more could be done to develop definite attitudes if every teacher could recognize that the formation of desirable attitudes is one of the primary objectives of education.

Gallagher (1969) found that high school students enrolled in physics and chemistry demonstrated more favorable attitudes toward science, science teachers, and "myself as a scientist." Students rated the personality dimension for science, scientists, and science teachers lower than other dimensions and perceived science, scientists, and science teachers as detached and unfriendly.

The following is just a sample of a large number of studies that dealt with factors which are of primary influence on attitude changes.

Welch (1969) examined factors which might be significantly related to satisfaction with high school physics. He found that expressed course satisfaction is only slightly related to initial ability in science, initial interest, attitude toward physics or general mental ability. Expressed course satisfaction is significantly related to success such as achievement gains. For students, it is not what students expect to happen that leads to satisfaction, but what actually does happen. One thing that does happen is that students often receive low grades relative to their grades in other courses and relative to their median I.Q.

Attitudes toward school subjects have been investigated extensively, and usually found to reflect the success of students in a particular subject. In other words, the total experience of the student with a subject, say physics, and his preference for the subject determines to some degree his success in it, and vice versa.

Poffenberger & Norton (1959) theorized that lack of interest in mathematics is a cultural phenomenon found both in our educational institutions and in our homes. Attitudes are developed by a variety of experiences. Some children develop attitudes in the home before they start school; others develop them as a result of their educational experiences with the subject matter and their teachers. By the time a student enters high school, and certainly by the time he gets to college, his attitude towards mathematics has already been formed and is difficult to change. It would be interesting to investigate the generalization of Poffenberger and Norton's theory as applied to science.

Some investigators see the teacher as the primary influence in developing positive attitudes toward science. His personality, his knowledge, and his own attitude are determining factors in whether his students have a positive attitude toward his subject area. Others stress the subject itself as the influencing factor. Poffenberger and Norton believe the home and general cultural climate to be of prime influence. All three points of view have something significant to say to educators. They point to areas which need further study and they suggest directions for changes in teacher selection and preparation and also in curriculum thrusts.

Ramsey and Howe (1969, p. 68), in an analysis of research on instructional procedures, wrote: "A student's attitude toward science may well be more important than his understanding of science: his attitudes determine how he will use his knowledge. For this reason the development of attitudes as a part of science instruction is an area requiring increasing research."

The extent to which student interests relate to student attitudes is very much a moot point. Yet it cannot be denied that the development of student interest in science is particularly difficult if students have negative attitudes toward science.

The research on attitude development still leaves many fundamental questions unanswered. The evidence is mounting that attitudes can be measured and that teaching procedures can be devised to bring about attitude change. However, much more work is needed to bring about a refinement of instruments and procedures. There is still a question about the relation between actual behavior and scores on written tests. Fundamental research must be done to find what relation exists between them.

B. Literature Related to Prediction of Student Changes

There will be no attempt to review all of the accumulated literature related to intelligence testing and the prediction of scholastic success. Rather, some of the more recent studies pertaining to general prediction problems will be reviewed in order to show the trends in this area. Also, a review will be made of differential prediction studies related to physical sciences and to reports using some of the variables used in the present study.

The idea of predicting general college success has received considerable attention since the development of intelligence and various standardized tests in the 1920's. These tests were used for admission purposes and the selection of students. MacPhail (1924) summarized almost every article concerning intelligence testing prior to 1924.

In reviewing the literature, it was found that there were many prediction studies reported during the period 1920-1943. A comprehensive review of over 700 prediction studies was made by Durflinger (1943). This review compared the results of correlating intelligence tests and achievement tests with college grades. Durflinger reported that the median correlation between intelligence test scores was about 0.45 with college grades. He also reported that higher correlations were obtained when a multiple correlation was made using a combination of intelligence tests, achievement test scores, and high school grades. The median of these multiple correlations ranged from 0.60 to 0.70.

Many studies have reported that the most useful item for predicting general college success is the high school achievement record, expressed either as a high school grade point average or rank in graduating class. Cosard (1953) summarized in tabular form the findings of thirty-five studies investigating the relationship between high school grades and college success. The correlation coefficient was found to be 0.53, while the range was from 0.41 to 0.68. The correlation of rank with college success ranged from 0.36 to 0.62.

Bou and Stovall (1950) reported that a single predictor, such as high school achievement, should not be used alone. They correlated the high school grade point average with high school size and obtained a median correlation of 0.57. They reported that grades "A" or "B" in a large high school carried more weight than the same marks in a smaller high school. Also, it was noted that students who had an average grade of "C" from a large high school were as successful in college as those who earned a "B" average in a high school with fewer than 300 students.

One of the most comprehensive reviews of the literature concerning factors related to scholastic success in college was reported by Garrett (1949). He lists five factors in order of importance for predictive value. These are high school scholarship, including rank in graduating class and grade point average (r=0.56), general achievement test scores (r=0.47), general aptitude test scores (r=0.43), and specific aptitude test scores (r=0.41).

Frederickson and Shrader (1952) reported the results of a comprehensive study made at twelve different schools across the country using the American Council on Education Psychological Examination (ACPE) along with the high school rank as predictor variables for college success. It was reported that high school marking suffered from the disadvantage that various secondary schools used grading systems which were very different. Rank in class overcame this difficulty and was presumably preferable to average grade. Frederickson and Shrader reported a large percentage of veterans on the campuses and believed it was necessary to consider the veterans and non-veterans separately. The median correlation obtained between the freshman grade point average and the ACPE was 0.49 for veterans and 0.45 for non-veterans. The use of rank as a predictor variable proved to be superior, with a median correlation of 0.53 for veterans and 0.60 for non-veterans. When the two variables were used jointly, the median correlation was 0.60 for male veterans and 0.68 for male non-veterans.

Bonner (1957) studied a sample of 260 freshmen, using high school rank along with other variables to determine which ones were the best for prediction purposes. High school rank in class was found to be the best predictor for first quarter college grade point average.

In the area of physics, there has been a long standing argument among college physics teachers as to the value of high school physics. Foster (1938) reported that students with high school physics as a part of their preparation had an average grade of 82.58 out of a possible 100, while those who had not taken high school physics had an average of 79.85. The influence of high school mathematics appeared to be negligible (r=0.13), but the influence of high school physics was quite high (r=0.70).

Hurd (1953, pp. 439-449) discussed the general state of the high school physics course and various studies relating to its value. He made the remark that "there is no real evidence that high school physics is essential to succesful work in college physics."

Easter (1954) studied a group of 166 women students of whom 85 had completed physics while in high school and 81 had not. He found the average grade point in physics of those who had had high school physics to be 2.41, while those who had not had high school physics were found to have a grade point average in physics of 1.64. After statistically eliminating the effect of the variable of intelligence, he found that the difference of 0.77 in the grade point was significant and concluded that a course in high school physics was valuable to college students of physics.

Renner (1965, p. 620) reported a survey conducted to determine the type of introductory physics courses offered in college physics departments. He questioned whether special courses were offered for those students who had completed high school physics. Analysis of the questionnaires indicated that very few colleges or universities offered special consideration to such students. In answer to the question: "Do colleges consider high school physics courses as being valuable enough to grant advanced standing in physics or to change the type of beginning physics course the student will take?" twenty-nine out of thirty-eight midwestern colleges and universities indicated that there was no need for such a course. Predicting success in the physical sciences with any accuracy has proved to be difficult. Prediction of success in English, the social sciences, the biological sciences, and mathematics has been shown more accurate than similar predictions in the physical sciences. This could be caused by the fact that students in physical science are more homogeneous in nature.

Giessow (1953) obtained predictions for freshman science courses by using nine predictor variables from high school records and seven from entrance examinations. The five natural science courses studied at Washington University in St. Louis were: basic physical science, general plant biology, general inorganic chemistry, general geology, and general physics. The predictor variables from the students' high school records were: total terms in mathematics and science; total grade points in general science, biology or botany, chemistry, physics, or some other science; grade point average in all sciences and mathematics; and percentile rank at high school graduation. Seven predictors from the scores in the Washington University Scholastic Aptitude Test were also used. These were reading, linguistics, reasoning, the Scholastic Aptitude Test, and quantitative, perceptual, and mechanical comprehension. For each course, the criterion was the letter grade earned at the end of the first semester. In the differential study, a multiple regression equation for predicting the general physics grade was developed. This included only two of the original predictor variables, namely the Quantitative Subtest and the grade point average in high school science. These two variables gave a multiple R of 0.79.

Another article which dealt directly with the measurement of student achievement in college physics was prepared by Kruglak (1965). This Resource Letter was prepared at the request of the American Association of Physics Teachers and supported by a grant from the National Science Foundation. It was one of a series of Resource Letters intended to guide college physicists to some of the literature that could improve course content. A list of seventy-eight articles was given, all dealing with the important area of testing for student achievement in college physics. The author reported that the grades received in physics courses were at best "an order of magnitude estimation" and that measurement of achievement in physics was still largely an unexplored area.

There have been a relatively small number of studies concerned with the prediction of success in college physics. Bolte (1966) used multiple correlation techniques to analyze the high school and college science and mathematics backgrounds of students who had completed the first semester of college physics. Only the following two variables of the original twelve variables remained as significant predictors of success in college physics: high school grade point and high school physics. The high school grade point average was the best predictor and the high school physics grade the worst predictor. Although high school physics was the least important of the five predictors, it remained a significant predictor. High school background in mathematics appeared to have no predictive value in determining success in college.

Sachtleben (1967) investigated the predictive value of the Scholastic Aptitude Test and the various background variables of high school and college work for success in the first semester of college physics. High school background in mathematics, chemistry, and biology, and also the size of high school class, were shown to be insignificant predictors for success in college physics. Converted high school rank was the most significant predictor. This variable included a measure of a student's attitudinal and motivational factors which had been present throughout his high school experiences. Advanced high school and college mathematics courses, along with physics, could be considered beneficial to the student of college physics. The SAT mathematics scores were of considerable predictive value, as were type of college and sex of the student.

Bolte's study at a large state university and Sachtleben's study at six liberal arts colleges indicated the common significant variables. The results showed that the high school grade point average or converted rank, courses in high school physics, freshman college mathematics, and college chemistry were all associated with success in college physics.

One of the most extensive studies by Adams and Garrett (1954) on beginning physics students at Louisiana State University showed that articulation between college physics and various types of high school work was poor, but that high school records were better predictors of success in college physics than entrance examination scores. It was indicated, however, that at least high school physics did not hinder the student of college physics.

Foster (1938) reported a partial correlation of 0.70 between success in general college physics and high school physics. At 0.77, the partial correlation between success in general college physics and native intelligence was, however, higher at 0.77. By way of comparison, it is interesting to note that the partial correlation between college physics and high school mathematics was only 0.13. Foster concluded that high school physics was not a negligible factor in the success of college students of physics.

Finger, Dillon, and Corbin (1965) studied success in college physics for students classified as to their high school background in physics. They used three groups consisting of students with PSSC physics, students with conventional physics, and students with no high school physics. The results generally implied that no significant difference in performance in college physics existed among the three groups.

A review of the literature reveals that the idea of predicting college success has been an important part of educational research since the development of standardized tests. Numerous studies have been conducted to predict general college success, but only within the past twenty years have studies been made dealing with differential prediction.

As one reviews the research done in this area, several weaknesses appear in many of the studies. Samples involving a relatively small number of students were noted. In those cases no statistical justification was attempted to validate the conclusions derived from the analysis of the sample data. Another weakness noted was that no test of significance was applied to the correlation coefficients. The correlation coefficient between the variables investigated and success in college was the usual method of showing relationships. The magnitude of the correlation coefficient was then used as an index of the predictive value of the variable. If no test of significance was performed, then little value could be placed in the results of the study.

As one reviews the literature in chronological order, he notices several trends. In the earlier studies only a few variables were used. This was caused, in part, by the long calculations involved. Recently, however, more variables have been used in the studies and the multiple correlations and regression equations can now be found by using advanced computer techniques. It is noteworthy, also, that throughout the years new variables continue to appear as different standardized tests become available. Therefore, constant research is needed in this area so that prediction techniques can be reviewed, revised, and updated by adding new variables as these new instruments become available.

C. Literature Related to Effect of Personality on Student Changes

Despite the critical importance of personal characteristics and a half-century of prodigious research effort, very little is known about the nature of personality. Most of the studies have not produced significant results. Many others have produced only pedestrian findings (Getzels, 1955).

A number of serious obstacles face the research-worker in the area of personality. Three problems illustrate the situation; i.e., the problem of definition, the problem of instrumentation, and the problem of the criterion.

There are profound differences in what is meant by the term "personality." Definitions are often contradictory; observations are often based on other definitions. In general, the more common definitions may be classified into two main categories: (a) behavioral definitions; that is, personality is the totality of a person's usual behavior; (b) social-stimulus definitions; that is, personality is defined by the response made by others to the individual. The problem is not that there are different conceptions of personality, but that researchers fail to distinguish one conception from another, and thus the data obtained from one definition are not differentiated from the data obtained in terms of another (Getzels, 1953).

Gowan (1964) theorized that the causal factors which allow individuals to assume their sponsoring roles in fostering creative work are deeply imbedded within their personality structures. While many writers have made this assumption, little experimental evidence is available to support their claim.

Rokeach (1959) has conceptualized dogmatism in terms of the degree to which a belief-disbelief system is "open" or "closed." For him, the basic characteristics that define the extent to which the belief system is open are a person's capacity to receive and to analyze stimulus information objectively, without distortion, and then to respond to the information on the basis of its own intrinsic merits, unimpeded by irrelevant factors in the situation which arise from within the person himself or from external factors. In this conceptualization, the more closed-minded an individual, the more difficult it is to distinguish between information received about the source and information received about the world. Conversely, the open-minded individual is better able to receive and analyze information objectively, to act upon the information independently, and to judge the information on its own merits.

The open-minded individual characterized by Rokeach needs the opportunity to make independent decisions, to plan his method of work, to observe and try to understand others, to analyze his own motives, and to engage in social activities in order to satisfy his needs. Conversely, other conditions such as explicit directions, encouragement, the completion of the task undertaken, and benevolent authoritarian leaders or supervisors are necessary in order that the closed-minded individual may satisfy his needs. For the optimum satisfaction of needs, those with closed minds require a different psychological climate. It is reasonable to expect that certain tasks may be accomplished satisfactorily by those with open minds, while these same tasks would be more difficult if performed by those with closed minds, and vice versa.

"Dogmatism" in the present study, as in Open and Closed Minds, refers to a closed way of thinking which can be associated with any ideology, regardless of content, an authoritarian outlook on life, an intolerance toward those with opposing beliefs, and a sufferance of those with similar beliefs. To say that a person is dogmatic or that his belief system is closed is to say something about the way he believes and the way he thinks - not only about single issues but also about networks of issues. The main concern is with the structure rather than the content of beliefs. (Within this framework it would be of interest to explore the relationship between belief and thought and the possibility that there is a basic unity between them. If something is known about the way a person believes, is it possible to predict how he will go about solving problems that have nothing to do with his ideology?)

At first glance rigid and dogmatic thinking appear to be synonymous; they both refer to resistance to change. Rokeach (1959), however, recognizes the distinction between "rigid" and "dogmatic" thinking. The first refers to the resistance to change of single beliefs (or sets of habits), and the second refers to the resistance to change of systems of beliefs. For example, it is ordinarily stated that a person is performing a task rigidly, not dogmatically. Thus, the referent of dogmatic thinking seems to be a total cognitive configuration of ideas and beliefs organized into a relatively closed system; rigidity, on the other hand, points to difficulties in overcoming single sets or beliefs encountered in attacking, solving, or learning specific tasks or problems.

Dressel and Mayhew (1954) observed that when confronted with problems, individuals in general behave as follows:

(a) They tend to avoid real problem-solving.

(b) They apply only a limited stock of techniques to solve them.

(c) They are satisfied with partial solutions.

(d) They change the problem completely.

(e) They escape from it entirely.

These behavior patterns indicate the influence of emotional factors on critical thinking. This relationship between personality and cognitive variables was first established by the research of Else Frenkel-Brunswik (1949) who found that as a result of early parent-child relationships, there emerges variance in ability of youth to tolerate ambiguity, and that this emotional and social ambivalence manifests itself in the cognitive spheres (thinking, perception, and memory). Postman and his associates (1948) concluded from their research that the individual establishes a perceptual defense against inimical stimuli. In his study of rumor, Allport (1935) observed that what leads to obliteration of some details and falsification of others occurs because the force of the intellectual and emotional context existing in the individual's mind leads to the assimilation of ideas in accordance with the values inherent within the individual. Thus, Maslow (1954) concluded that individuals ward off threatening aspects of reality which at the same time provide the individual with a compensatory feeling that he understands it. This form of thinking is referred to as dogmatic.

Such behavior patterns as those listed above lower the individual's efficiency in critical thinking. When they are examined, it is noted that emotional effects exert a pervasive influence on the outcome. Individuals apparently try to cope with a situation through the use of distortion, narrowing, or withdrawal. They do not tolerate ambiguity and move toward "closure" without sufficient consideration of the various aspects of the problem necessary to solve it. Of course, others confront a new experience very differently; they approach it in all its details. They analyze, evaluate, discard, or integrate part or all of it. The more open-minded the individuals, as measured by the Dogmatism Scale, the more perceptively they examine different aspects of the experience, try to clarify the ambiguity, and strive to see the relationship among the parts.

Solomon (1953) found that open-minded college students, as measured by the Dogmatism Scale, showed greater ability to discard preconceived ideas and to integrate or accept new and scientifically demonstrated facts. These open-minded persons in whom there is almost a complete absence of defenses and an increase in spontaneity and honesty, resemble the self-actualizing individuals described by Maslow (1954). The distinct difference in the approach to critical thinking as measured by *WGCTA* between the open and closed minds led to the assumption that in situations requiring the performance of higher thought processes, the low-dogmatic individuals would be more efficient than the high.

There is some evidence that a measure of rigidity might serve as a somewhat rough index of creativity. Fleming and Weintraub (1962) discovered a moderately negative relationship (r = 0.41) between rigidity and verbal creativity among children.

Kemp (1960) compared those students who were low with those who were high in dogmatism, with reference to their ability in critical thinking as indicated in problem-solving. Five hundred college freshmen were used in the sample, and each student participating in the study was administered the *Dogmatism Scale*, Form E, developed and standardized by Rokeach (1959). The *Dogmatism Scale* was used as a means of classifying the student's dogmatism. Fifty problems in critical thinking involving analysis and evaluation were administered to the students. Both students with the highest and lowest scores in relation to dogmatism were selected for this comparison.

Kemp found that in critical thinking, the low dogmatics are more successful than the high.

Kemp (1964) showed that open-minded and closed-minded students, as measured by the Dogmatism Scale, differ significantly in character and degree. A random sample of 120 university students of both sexes was used in the study. The open-minded have a greater need for autonomy, dominance, intraception and heterosexuality; the closed-minded have a greater need for nurturance and endurance.

Adorno, Frenkel-Brunswick, Levinson, and Sanford (1950) hypothesized that some individuals are consistently rigid, anxious, and generally receptive to authoritarian statements. At the opposite extreme there are individuals who tend to reject authoritarian statements and might be described as flexible.

A review of the literature reveals numerous studies that have explored the relationship between various aspects of the academic background of students and their achievements. There are, on the other hand, only a very few studies designed to determine the relationships between student personality and his learning and attitude toward such learning. Thus, to research the outcomes of such an attempt has been an obvious impossibility. Since the majority of the subjects in the present study are prospective elementary teachers, a review of some of the most recent studies pertaining to teacher personality and its relationship to learning might be informative in giving a clue to the relationship between student personality and his learning.

The American Educational Research Association (1952, 1953) stated the main reason for conceptual and experimental limitations of research on personality and student change: research in this field is conducted in a theoretical vacuum. Investigators are busy seeking *ad hoc* solutions to immediate problems with little regard to the theoretical meaning or long-range fruitfulness of the findings. Hypotheses are based upon over-simplifications of personality, leading to inadequate methodology and to conclusions which make neither psychological, sociological, nor common sense. The authors concluded that only by working with the context of sound theory can one hope for useful, relevant, and widely applicable findings (American Educational Research Association, 1952).

Getzels and Jackson (1967) argued that cognitive variables usually do not correlate with pupil growth as measured by changes in behavior. Much remains to be learned about the art of systematic classroom observations. The teacher's behavior changes when an observer is present and the observer can sample only a small part of the teacher's repertoire.

In a national sample of physics classes, Rothman, Walberg, and Welch (1969) examined the relationship between teacher characteristics of training, experience, attitudes, personality, and values, and these areas of student learning: achievement, interest in and understanding of science, and attitudes toward physics and teaching. Rothman _et al_., 1969, found that the teacher's personality and value system is more strongly related to students' achievements in physics, attitudes toward physics, and interest in science than the teacher's preparation in physics, mathematics, history and philosophy of science, his knowledge of physics, or years of physics teaching experience.

Rothman (1969), examining the relationships between teachers' backgrounds, personalities, and attitudes toward physics and student learning, found also that students acquire more knowledge about physics when taught by teachers with extensive preparation in physics and mathematics. However, these same students appear to lose interest in physics. Students of some teachers who find mathematics and physics understandable and important, report that they have found physics less interesting. Rothman reported a significant relationship between teacher personality, as measured by the Edwards Personal Preference Schedule (EPPS) and Allport-Vernon-Lindzey Study of Values (AVL), and students' cognitive learning, as measured by the Test on Understanding Science (TOUS), the Welch Science Process Inventory (WSPI), and the Project Achievement Test (PAT). The joint action of the teacher personality variables accounted for 70.6 percent of the variance in the three measures of cognitive learning. However, the report indicated that no overall relationships exist between the teacher personality variables and changes in student attitudes and interests.

One personality characteristic that has received some consideration in the past few years is dogmatism or the degree of open- and closed-mindedness within the belief system. The importance of open-mindedness for tasks involving personal interaction, leadership, and social understanding seems incontestable. Several writers, including Barr & Eman (1930); Charters (1929); Weir (1963); and Wendt (1961) have suggested that open-mindedness is a most important variable in promoting a good instructional climate at all levels of learning.

While dogmatism is being investigated as a student characteristic affecting learning under different teaching methods, a more specific theory about the conditions which are effective in producing learning for students of high and low dogmatism is needed.

Ackerman (1954) reviewed more than thirty studies that attempted to relate teacher characteristics with the criterion "measured student change." These studies used student attitude towards teachers, teaching experience and preparation, teacher age, intelligence, professional information, personality, social attitudes, and relationships with pupils as dependent variables. The author concluded that, in general, the results were contradictory and inconsistent. Inconclusive and conflicting results have often been reported (Davis, 1964; Schmedemann, 1967).

Yager (1966) found that the individual teacher affects the outcome of instruction in science, the growth of critical thinking, the understanding of the nature of science and scientists, and student attitudes toward a given course. A teacher can be strong in stimulating a particular outcome of learning in his students while being weak in another aspect. Yager recommended that specific traits of teachers should be studied in order to establish patterns producing desirable results in student achievement. Such information would be invaluable in the recruitment of persons to the teaching profession, to in-service experience, and to pre-service training.

As the focus shifts to student characteristics, research designs should employ teaching method variables and dimensions of individual differences bearing some theoretical relationship to one another, as suggested by Cronbach (1971).

CHAPTER III

METHODS AND PROCEDURE

A. Selection of the Sample

The sample selected for this study consisted of students enrolled in the course called "Thought and Structure in Physical Science"(LAS 140) designed for non-science majors at the Urbana-Champaign Campus of the University of Illinois during the fall semester of the 1971-72 academic year. Four hundred and seventy-one students were included in the sample. The class was composed of eighty-four percent freshmen and sophomores, sixteen percent juniors and seniors. Although ninety-nine percent of the students came from the State of Illinois, the remaining one percent of the students graduated from high schools in fifteen different states. One of the targets for the course was prospective elementary teachers, which accounts for the fact that sixty percent were elementary education majors. The students were randomly assigned to the three lecture groups and to the several discussion and laboratory sections. Forty percent of the enrollees were women. The philosophy and objectives of the "Thought" course can be found in Appendix B on pages 178 through 184.

B. Selection of the Variables

When one attempts to select the independent variables, it is necessary to make some preliminary decisions. Since it was not possible to consider all academic, biographical, and personal characteristics, it was necessary to establish some guidelines for the selection of the variables. The guidelines established are listed below:

1. It must be possible to express the variable as a numerical value.
2. The variable must be available for a large number of students.
3. The variable must be related in some way to each of the dependent variables.
4. The variable is relevant in the judgment of the investigator and the teaching staff.

The last two of these guidelines require personal judgment based on the experience and interest of the investigator in teaching physical science to non-science majors. The variables chosen for this study include some factors which were found to be important in previous investigations and some which seemed to be peculiar to the theoretical framework of the course and more modern objectives in science teaching.

It was of particular interest to determine what fraction of the total effect various high school and college science and mathematics courses had on student changes. For example, it might be expected that high school mathematics courses would affect a student's later performance in college physical science. These courses have considerable interrelation based on various reports in the literature. The various mathematics and science courses were chosen for variables because of the presupposition generally held by many students and instructors, that previous high school courses in mathematics and the sciences are prerequisite to success in college physical science courses.

The majority of the colleges throughout the country use some form of entrance examination. The University of Illinois uses the American College Testing Program (ACT) examinations. Because of the widespread use of this examination, the scores were included as variables.

On the basis of the considerations indicated above, data were secured and recorded on IBM cards concerning the twenty-six independent variables and the four criterion measures listed in Chapter I on page 6.

Although the grade is a universal way of rating the academic success of students, this investigator chose not to use it for several reasons. The staff in the course deemphasizes grades as an indicator of success and puts more emphasis upon generating diversity. The staff also feels that a properly designed curriculum should assure success for all individuals but not in the same manner. In other words, the staff claims to be concerned not so much with teaching the "right brand of physical science" as they perceive it, but with examining what Polyani calls "personal knowledge." They are interested in the nature of evidence relative to each student's conceptual view. They feel that this method will allow the student to operate within assumptions of his own, and would also allow him to defend a choice most consistent with his own view. It is also possible that variations in grading procedures between instructors might affect the criterion variable.

The number of hours of science and mathematics courses was chosen as a variable because the interest in this study was to compare the effect of academic and personal characteristics of students on learning. Instead of using previous achievement in each high school course, the quality of student work is considered on a more general basis by using high school rank of the students.

Previous investigators, including Naibert (1964), Dyer (1952), and Fricke (1958), used the College Entrance Examination Board verbal and mathematics scores to predict general college success. These scores have also been used for differential prediction in the area of chemistry. Since the University of Illinois required ACT scores for admission purposes, it was decided to use these scores as predictor variables.

From the previous discussion concerning the variables in this study, the following understanding should be stressed. It is not implied that the variables being considered, in relation to each of the dependent variables, are the only ones which are actually related. Instead, these are the variables which lend themselves to a reasonably accurate measurement and satisfy the four assumptions stated at the beginning of this chapter. They can also be treated statistically by using computer techniques.

C. Instrumentation

Each of the six instruments was selected to measure a particular aspect of interest in the study. Five instruments were used on a pretest - posttest basis. Only the CPI was administered on a pretest basis. The six instruments used in the study are:

1. Test on Understanding Science, Form W (TOUS)
2. Watson-Glaser Critical Thinking Appraisal, Form YM & ZM (WGCTA)

3. *Silance Attitude Toward Any School Subject*, Forms A & B Short Forms (*Silance*)
4. *Student Perception of Teacher Style* (*SPOTS*)
5. *Dogmatism Scale*, Form E (*DS*)
6. *California Psychological Inventory* (*CPI*)

Specific statistical data concerning the four instruments are summarized in Appendices C through G. Brief outlines of the various instruments follow.

Test On Understanding Science

The *Test On Understanding Science* (*TOUS*) was developed to meet a definite need. During the years preceding the development of this test in 1961, evidence mounted that pupils' understanding of science and scientists was disappointing despite increased exposure to science. Suggestions were made that historical materials or an investigative approach might be effective in attaining these important instructional outcomes. But a valid instrument was needed to evaluate outcomes in this realm. In fact, Cooley and Klopfer (1961) developed the test to evaluate their own use of case histories in the various areas of secondary school science instruction. The *Test On Understanding Science* (*TOUS*) has a reliability of 0.76. The definition of understanding of science is illustrated by the following themes (Cooley, Klopfer, 1961, pp. 3-4).

The major themes measured by TOUS are divided into three areas as follows:

1. Understanding about the scientific enterprise
    - a. the human element in science
    - b. communications among scientists
    - c. scientific societies
    - d. instruments
    - e. money
    - f. the international character of science
    - g. the interaction of science and society
2. Understanding about scientists
    - a. generalizations about scientists as people
    - b. institutional pressures on scientists
    - c. abilities needed by scientists
3. Understanding about the methods and aims of science
    - a. generalities about scientific methods
    - b. tactics and strategy of sciencing
    - c. theories and models
    - d. aims of science
    - e. accumulations and falsification
    - f. controversies in science
    - g. science and technology
    - h. unity and interdependence of the sciences

Watson-Glaser Critical Thinking Appraisal

The Watson-Glaser Critical Thinking Appraisal is a widely used instrument recommended by its authors "... as a research tool to determine the relationships between critical thinking abilities and other variables or traits." (Watson & Glaser, 1952, p. 9) They further define what the test measures:

> . . . The total score yielded by the test represents a valid estimation of the proficiency of individuals with respect to these aspects of critical thinking:
> 1. The ability to define a problem.
> 2. The ability to select pertinent information for the solution of a problem.
> 3. The ability to recognize stated and unstated assumptions.
> 4. The ability to formulate and select relevant and promising hypotheses.
> 5. The ability to draw a valid conclusion and to judge the validity of inferences. (Ibid., p. 9)

Watson and Glaser (1964) state that: "The stimulus situations are similar to those which a citizen in a democracy might encounter in his daily life as he works, reads a newspaper or magazine article, hears speeches, participates in discussions on various issues." (p. 2) Forms YM and AM were used as pretest and posttests. Forms YM and AM have reliabilities of 0. 86 and 0.77 respectively. The odd-even split half formula as corrected by Spearman-Brown was used.

A Scale to Measure Attitude Toward Any School Subject

The Silance: Attitude Toward Any School Subject instrument (Silance, 1960) was developed to determine subject preferences of students. The subject chosen for this study was physical science designed for non-science majors. The Silance score was computed by finding the median response or responses for the subject. The score for that subject was determined by a predetermined value for each median response. If there were an even number of responses, the values of the median scores found on the score sheet were added together and then divided by two. Often the score was rounded off to one decimal place. The scores for each subject were ranked.

Equivalent forms were developed for this test, with reliability ranges from 0.81 to 0.70. They were computed by using different school subjects. The reliabilities reported for biology, chemistry, English, and mathematics follows:

	Subject	Reliability	No. in the sample
1.	biology	r = 0.81	(n = 269)
2.	chemistry	r = 0.70	(n = 771)
3.	English	r = 0.74	(n = 705)
4.	mathematics	r = 0.74	(n = 579)

The reliability for college physical sciences is not reported in the literature.

This scale was the basis for the revised, shorter scale developed by Silance (1960) to measure attitudes toward any school subject. The exact population upon which the scale was constructed is uncertain, but it was apparently a large sample (several thousand) of high school students and college undergraduates. Shaw and Wright (1967) claimed that the scale had adequate content validity. The original reliability of the scale is not reported in the literature.

Student Perception of Teacher Style (SPOTS)

Student Perception of Teacher Style (*SPOTS*) is an instrument which measures student attitude toward instructional climate (Tuckman, 1970). Previous attempts with similar objectives (Lewin, Lippitt, & White, 1939; Wispe, 1951) employed detailed narrative accounts in an effort to deal effectively with a large sample of behavior. More widely accepted techniques for studying teaching style have been developed (Amidon, & Flanders, 1963; Medley, & Mitzel, 1963; Perkins, 1964). The Amidon-Flanders approach requires trained observers to enter classrooms, categorize the verbal behavior of the teacher, and produce matrices of the verbal responses. In contrast, the Medley-Mitzel Oscar technique necessitates the observation of "signs" of specific behavior by trained observers in the classroom. Both techniques offer objectivity at the expense of efficiency.

Remmers (1963) suggested that: "Many of the variances in research on teaching are so complex that tests, questions, and objective behavior records are either inadequate or too inconvenient."(p. 329). Alternatively, he proposed that sensitive, complex, and alert human observers become the recording instrument, and that scales be the method of communication. However, other rating scales developed (Christensen, 1960; Solomon, 1964) seemed to confound the concept of directiveness with other evaluative dimensions of teacher behavior, such as competence.

Classroom observation plus an examination of the literature led to an operational definition of directive teaching, emphasizing structure and interpersonal relationships in the classroom. The following illustrate the SPOTS concept of directive teaching:

1. formal planning and structuring of course work
2. minimization of informal work or small group work
3. rigid structuring of small group work wherever such is employed
4. rigid structuring of individual and classroom activities
5. emphasis on factual knowledge or knowledge derived from sources of authority (books, school administrators)

6. use of absolute and justifiable punishment
7. minimization of the opportunity to make and to learn from mistakes
8. maintenance of formal relationship with students
9. assumption of total responsibility for grade
10. maintenance of formal classroom atmosphere

The student rating scale developed consists of seventeen items, each describing a facet of classroom behavior indicative of the directiveness or non-directiveness of teaching style, based on the above operational definition. The SPOTS test requires students to rate the intensity or frequency of specific teacher behavior on a nine-point rating scale.

The SPOTS test appears to satisfy the five criteria (Remmers, 1963) for judging the adequacy of student rating scales in the following ways: (a) objectivity: it yielded verifiable and reproducible data; (b) reliability: it was consistent (r = 0.69 - 0.98, where r is the interjudge reliability coefficient); (c) sensitivity: it discriminated between both teachers and teaching styles; (d) relevance: it was related to the construct of directiveness (closed classroom climate); (e) utility: it was high in efficiency and in practicality.

Dogmatism Scale (*DS*)

The *Dogmatism Scale*, Form E, was developed (Rokeach, 1959) to identify open and closed belief systems. The scale focuses on the *structure* of the belief system rather than on the content of ideological systems; it emphasizes how individuals believe, rather than what they believe. The *Dogmatism Scale*, Form E, consists of forty Likert-type items, to which subjects respond by means of a six-element key ranging from "I agree with the statement" to "I disagree with the statement." Scores might range from 40 to 280, with a high score representing extreme closed-mindedness and a low score indicating an open mind. High scores are interpreted as showing dogmatism and lack of receptiveness to new ideas; low scores are interpreted as showing flexibility, adaptability, and receptiveness to new ideas. The scale is scored by the method of summated ratings where the higher the score, the greater the degree of closed-mindedeness. Five editions of the scale are available. The aim of these revisions was to take advantage of continuing refinements in the theoretical formulations and to increase reliability. The final forty-item scale, Form E, was found to have a corrected reliability of 0.81 for the English college and 0.78 for the English worker sample. In other samples subsequently tested at Michigan State University and at Ohio State University, the reliabilities range from 0.68 to 0.93 (Rokeach, 1959, p. 90). These reliabilities are considered satisfactory, in view of the fact that the Dogmatism Scale contains an eclectic collection of writings which on the surface appear to be unrelated to each other.

California Psychological Inventory (CPI)

The California Psychological Inventory (Gough, 1960) was developed to measure a set of eighteen personality characteristics important in social living and social interaction. The inventory is mainly concerned with those characteristics of personality which have a wide and pervasive applicability to human behavior and which, in addition, are related to the favorable and positive aspects of personality rather than to the morbid and pathological. A second goal for the CPI was the practical one of devising brief, accurate, and dependable subscales for the identification and measurement of the variables chosen for inclusion in the inventory. Based on the sample used in this study, the reliability for the nine subscales range from 0.47 to 0.67. A further consideration was that the instrument be convenient, easy to use, and suitable for large-scale application.

The test booklet contains 480 items and yields eighteen standard scores. Each scale is intended to consider one important facet of interpersonal psychology; the total set of eighteen is intended to provide a comprehensive survey of an individual from the social interaction point of view.

Norms for the CPI were developed from consolidation of the available samples into a single composition sample for each sex. Standard scores for males are thus based on more than 6000 cases, while female norms include more than 7000. These totals are fairly large and include a wide range of ages, socio-economic groups, and geographical areas. The CPI has been administered to over 50,000 subjects. Gough (1960) reported reliability ranges of 0.60 - 0.74 for males and 0.57 - 0.77 for females for the nine subscales selected for this study.

The names of the scales were carefully chosen to describe as closely as possible the kind of behavior they were designed to reflect. The meaning is made clear by a knowledge of the definition or purpose of the scale, which in most cases suggests the kind of criterion groups used in developing it. Appendix C on page 185 gives the scale definitions which are supplemented by a listing of characteristics frequently associated with high and low scores on each measure.

Factor analysis of the CPI (Mitchell, Pierce-Jones, 1960) yielded four factors, one of which is called "Capacity for independent thought and action." This factor, which is of special interest in this study, consists of the following CPI scales: Capacity for status (Cs); Social presence (Sp); Tolerance (To); Achievement via independence (Ai); Intellectual efficiency (Ie); Flexibility (Fx). Three additional CPI scales, Self-acceptance (Sa), Responsibility (Re), and Achievement via conformance (Ac) were added to the above set of six CPI scales because they are relevant to the criterion measures in this study.

D. Experimental Procedures

Most common of the scientific statistical procedures is that of the control group experiment wherein one group utilizes one curriculum and an equated group utilizes another. When there are extensive differences in the curriculum objectives, as was the case with the "Thought" course, it is difficult to devise tests or other evaluative criteria with which valid comparisons with a control group are possible. To compare the "Science Thought" course at the University of Illinois with a "traditional" physical science course may not be very different from asking whether Method A is as effective in teaching English as Method B is in teaching history.

Heath (1962) suggested that instead of attempting to carry on comparative curriculum experiments in a vain attempt to decide which is better, attention should be directed to determining the characteristics emphasized in the curricula and the effect of these curricula on student enthusiasm for the subject matter.

Because of these considerations, the One-Group Pretest-Posttest design presented by Campbell and Stanley (1963) was used in this study. At the same time, the limitations of the one-group study should be recognized. In particular, it is difficult to attribute the growth to the course in physical science. All other experiences may have been just as effective as the science course.

This study is not unique in using the One-Group Pretest-Posttest design; many investigators (Finger, Corbin, & Dillon, 1965; Tamir, 1969; Whelchel, & Pettus, 1970) have abandoned the task of comparing two types of curricula. The results usually reveal no significant differences; or worse, they produce conflicting findings.

The 0.05 level was used to determine significance throughout all the analyses. An F Value greater than the tabled value indicates significance and is marked with an asterisk in the tables. A t-value greater than the tabled value also indicates significance and is marked with an asterisk in a similar manner.

For the purpose of this study, student changes are measured by the differences between the postscores and prescores on each of the four criterion variables. The analyses will be discussed in the following order:

1. Type I Design for Analyzing Student Changes

This analysis corresponds to the first step of the Purpose of Study, Chapter I. Type I design, as designated by Lindquist (1953), was used for pre- and posttest mean scores on the four criterion measures and the Dogmatism Scale. This design is basically a two-factor design in which each of the A treatments in combination with any one B treatment is administered to a different group of subjects. The total experiment may thus be regarded as consisting of three experiments of treatments by subjects, the first experiment with B held constant at the B_1 level, the second experiment at the B_2 level, and the third experiment at the B_3 level. The treatment by subject design was used for pretest and posttest analyses for each instructor for which the interaction term was significant. The treatment by subject analyses were made in order to gain additional insight into the nature of the changes. The significance of the interaction, if it exists, would be equivalent to the conclusion that the mean growth from pretest to posttest was not identical for the three instructors.

2. Multiple Regression Analysis for Predicting Student Changes

When an analysis is made to determine the relationships between several variables in this study, it is unlikely that each of the variables will be independent of every other variable. For example, it must be taken into account that the relationships between two variables such as high school mathematics and intelligence are undoubtedly interrelated with a third variable such as the ability to think critically. There is a high zero order correlation between high school hours in mathematics and scores on critical thinking. This may imply that intelligent students are the ones most likely to take mathematics, and that these intelligent students will do well on critical thinking tests. The importance of mathematics as related to the ability to think critically might be negligible.

Multiple regression analyses provide a means of defining the best combination of variables to predict a given criterion. In the present study there are four dependent variables. These techniques take into account the interrelation among the individual predictors. Some of the basic theory of multiple regression analysis and stepwise regression analysis (SRA) will be discussed in order that the final results can be clearly understood.

SRA analysis was used to study the interrelation of two or more independent variables to a dependent or criterion variable. The value of SRA is that a sequence of multiple linear regression equations are computed in a series of steps. At each step, the variable which makes the greatest reduction in the squared errors of prediction is added to the equation. It is the variable which has the highest partial correlation with the criterion, given those that have already been added. It is also the variable which, if it were added, would have the highest "F" value for added regression. An independent variable that has been tentatively accepted into the prediction equation will be removed from the regression equation if the "F" value falls below a stated level. A more complete description of the Fortran IV program can be found in Selected Statistical Programs, edited by Snider and Thomas (1970).

The stepwise regression analysis was made for each of the four dependent criterion measures. These include gains on *Test On Understanding Science* (*TOUS*), *Watson-Glaser Critical Thinking Appraisal* (*WGCTA*), *Attitude Toward Any School Subject* (*Silance*), and *Student Perception of Teacher Style* (*SPOTS*). This analysis provides a way of reducing a large array of independent (predictor) measures to a relatively small and efficient set of independent variables with little or no loss in predictive accuracy.

When this regression analysis is done by the IBM 360/65 computer and tests of significance are made, the relative importance of significant independent variables are determined.

The analysis of this step was further divided into the following:

a. Given all the twenty-six independent variables (thirteen academic, three identified for the three instructors, and ten personal), the stepwise regression analysis was made to identify the subset of independent variables which contribute significantly in predicting the growth of each of the four dependent variables.

b. Given only the thirteen academic and identification variables, the stepwise regression analysis was made to identify the subset of independent academic variables which contribute significantly in predicting the growth on each of the four dependent variables.

c. Given the personal variables and the instructor variables, the stepwise regression analysis was made to identify the subset of independent personal variables which contribute significantly in predicting the growth on each of the four dependent variables.

d. Combining the thirteen academic variables and the three instructor variables with ten personal variables, the stepwise regression analysis was made to identify what significant contribution would be attained by adding the instructor variables and then the ten personal variables to the battery of predictors that already includes the academic variables. This step was repeated for each of the four dependent variables.

Items one through twenty-six listed in Appendices H through K are considered to be the independent variables. The meaus of independent variables are listed in Appendix L. Test items of *SPOTS* are listed in Appendix M. Appendices N through Q include the correlation matrices of all predictors and each of the four dependent variables.

Three variables were introduced to identify the three instructors teaching the course. These variables were labelled by the variables numbered fourteen, fifteen, and sixteen for instructor #1, instructor #2, and instructor #3 respectively. They were quantified in the following way:

1. If the student were enrolled with the first instructor, a score of one was given to variable fourteen and a score of zero was given to variables fifteen and sixteen.

2. If the student were enrolled with the second instructor, a score of one was given to variable fifteen and a score of zero was given to variables fourteen and sixteen.
3. If the student were enrolled with the third instructor, a score of one was given to variable sixteen and a score of zero was given to variables fourteen and fifteen.

One should be very cautious in interpreting the significance of the three predictors associated with the three instructors. While there are several psychological reasons to believe that the instructor contributes significantly in predicting student changes, it is statistically difficult to attribute the results to that instructor only. Other factors may also be involved. For example, students enrolled with different instructors might significantly differ on their scores on the independent variables. Also, the three instructors lectured to three sections which were held at 9:00 A.M., 11:00 A.M., and 2:00 P.M.; thus, the time of lectures was confounded with instructor. Results obtained by introducing three variables associated with the three instructors could have been obtained by using only two variables. Because of the above considerations, the predictors associated with instructors should not be treated with the same emphasis and implications as the other predictors.

3. Covariance And Simple Randomized Design for Analyzing the Effect of Personality on Student Changes

In order to test the null hypotheses set forth in step five of the Statement of Research Hypotheses, Chapter I, using the pretest scores on the criterion instrument as control measures, several investigators would suggest that the analysis of covariance would be the proper analysis. However, Feldt (1958) indicates that:

> heterogeneous regression renders the covariance technique, as it is typically applied in educational and psychological research, somewhat invalid....If the usual covariance model is used, the effects would appear to be more serious than those of non-normality and heterogeneity of variance are to an analysis of variance. In cases of heterogeneity of regression, the obtained error variance would probably overestimate the true error variance, and thus increase the probability of retaining a false null hypothesis (pp. 351).

In order to decide which analysis would result in greater precision, Feldt (1958) concludes that:

> For $\rho < .4$ the factorial approach results in approximately equal or greater precision than covariance, for $\rho \geq .6$ the advantage is in favor of covariance. For relatively high values of ρ and relatively small values of N, the difference in precision is appreciable. This difference is mainly attributable to the fact that relatively small values of N do not permit the experimenter to employ a sufficiently large number of levels to exploit fully the value of the control variable. However, the marked superiority of covariance occurs for values of ρ which are rarely encountered in educational and psychological experiments. It may also be noted that for $\rho < .2$ and small values of N neither covariance nor the factorial design yields appreciably greater precision than a completely randomized design (pp. 347).

The correlation coefficients between pretests and posttests of the four criterion measures are listed in Table 35 on page 133. In order to test the null hypotheses set forth in step five of the Statement of Research Hypotheses, Chapter I, with greater precision according to the above discussion, the analysis of covariance was used for TOUS and WGCTA; the completely randomized design was used for Silance and SPOTS.

CHAPTER IV

ANALYSIS AND INTERPRETATIONS OF RESULTS

For the purpose of this study, student changes are measured by the differences between the postscores and prescores on each of the four criterion variables. The analyses will be discussed in the following order:

A. Type I Design for Student Changes
(The treatment by subject design was made for each instructor on the subtests for which the interaction was significant.)

B. Stepwise regression for the problems of prediction and correlation.

C. Analysis of covariance and simple randomized design to test the significance of six selected personality and identification factors.

A. Type I Design for Analyzing Student Changes

Tables 1 through 22 on pages 88 through 109 include the results of pretest-posttest analysis for the four criterion measures and the Dogmatism Scale as they are applied to students in this study. The results of the analyses at the five percent level indicate the following:

1. There is a significant increase in understanding of science as measured by TOUS (Subscore I)
2. There is no significant difference in understanding of scientists as measured by TOUS (Subscore II)
3. There is a significant increase in understanding of the scientific process as measured by TOUS (Subscore III)
4. There is a significant decrease in the ability to draw valid inferences as measured by WGCTA (Subscore I)
5. There is a significant decrease in the ability to recognize assumptions as measured by WGCTA (Subscore II)
6. There is a significant decrease in the ability to reason deductively as measured by WGCTA (Subscore III)
7. There is a significant increase in the ability to interpret as measured by WGCTA (Subscore IV)
8. There is a significant decrease in the ability to evaluate arguments as measured by WGCTA (Subscore V)
9. There is significant growth in the positive attitudes of students towards open instructional climate as measured by SPOTS.
10. There is no significant growth in the positive attitudes of students towards the physical

science course as measured by Silance.

11. Designating the pretest-posttest factor as A, and the instructor factor as B, there is a significant interaction (A x B) for TOUS (Total Test, Subtest #1), WGCTA (Subscore I), and SPOTS. Now the conclusion that mean growth from pretest to posttest was not identical for the three instructors can thereby be advanced.

In order to gain additional insight into the nature of the changes, a Treatment by Subject (T x S) analysis was made of the data for each instructor. This analysis is recommended for each instructor on the subtests for which the interaction was significant. The results presented in Tables 14 through 22 on pages 101 through 109 indicate:

1. There is significant growth in understanding science as measured by TOUS (Total Test, Subtest #1) for instructor #3 only.
2. There are significant decreases at the 0.05 level in critical thinking ability as measured by WGCTA (Subtest #1) for instructors #2 and #3.
3. There are no significant differences at the 0.05 level in critical thinking ability as measured by WGCTA (Subtests #1) for instructor #1.
4. There are significant differences in the attitudes of students toward open instructional climate as measured by SPOTS for all instructors.

5. There are no significant differences in the attitudes of students toward the physical science course for instructors #2 and #3.
6. There is significant decrease in positive attitudes of students toward the physical science course for instructor #1.

The significance of the interaction terms indicates that mean growth from pretest to posttest is not identical for the three instructors. The three instructors lectured to three sections at three different times. Thus, time of lectures was confounded with instructor.

The significant positive growth on TOUS (Subtest I) for instructor #3 can be explained in two parts; first, by the large differences in amount of teaching experiences between instructor #3 and other instructors; and secondly, by the growth scores on SPOTS which reveal that instructor #3 has the highest open instructional climate.

The significant decrease on WGCTA could be viewed by reviewing the objectives of the course on page 182. The student would be expected to receive a positive gain score if the instruction were focused towards achieving the "right" answers. The staff of the course is concerned with examining how well the student can handle his own viewpoint. Thus, instead of a text-book "right" of "wrong" answer, the student is permitted to find his own answers; and he is also required to defend his position by reasonable arguments. In short, the staff tries to move the student away from the tradition of the single, absolute, correct answer to a problem (to which he has been generally conditioned by previous education.) The above explanation is in agreement with results on pre-posttests on *SPOTS*, *Silance*, and T x S design. The data on *SPOTS* reveals that instructor #3 has the highest open instructional climate. Results on T x S design indicate that instructor #3 has the greatest loss with the *WGCTA*. The results on *Silance* indicate that while there are significant differences in the attitude of students toward the course enrolled with instructors #2 and #3, there is significant decrease in the attitudes of students enrolled with instructor #1. Thus, the more open the instructional climate is, the further away the students were moved from the tradition of the single, absolute, correct answer, and the more encouragement to the students to find their own answers. This, consequently, could explain the large negative growth on *WGCTA*, since score on *WGCTA* is in agreement with the given correct answers. The writer suggests the need for additional tests capable of detecting changes in student's behaviors with little emphasis on "right" or "wrong" answers and major emphasis on allowing the student to defend choices most consistent with his own view.

TABLE 1

ANALYSIS OF TOUS PRETEST - POSTTEST (TOTAL TEST)

Sources	DF	SS	MS	F RATIO
B	2.	9.50	4.74	0.0645
Error (B)	225.	16557.56	73.59	0.0
A	1.	92.16	92.16	4.4780*
AB	2.	128.73	64.36	3.1274*
Error (A)	225.	4630.61	20.58	
Total	455.	21418.56	47.07	

Group	PRETEST means	POSTTEST means
Instructor 1 (B1)	36.73	36.55
Instructor 2 (B2)	36.71	36.91
Instructor 3 (B3)	35.90	38.13

TABLE 2

ANALYSIS OF *TOUS* PRETEST-POSTTEST (FIRST SUBTEST)

Sources	DF	SS	MS	F RATIO
B	2.	6.22	3.11	0.2924
Error (B)	225.	2391.64	10.63	0.0
A	1.	40.56	40.56	9.0519*
AB	2.	29.21	14.61	3.2598*
Error (A)	225.	1008.22	4.48	
Total	455.	3475.86	7.64	

Group	PRETEST means	POSTTEST means
Instructor 1 (B1)	12.06	12.06
Instructor 2 (B2)	11.67	12.00
Instructor 3 (B3)	11.48	12.69

TABLE 3

ANALYSIS OF *TOUS* PRETEST - POSTTEST (SECOND SUBTEST)

Sources	DF	SS	MS	F RATIO
B	2.	1.85	0.92	0.0961
Error (B)	225.	2161.99	9.61	0.0
A	1.	0.14	0.14	0.0327
AB	2.	12.45	6.22	1.4519
Error (A)	225.	964.41	4.29	
Total	455.	3140.83	6.90	

Group	PRETEST means	POSTTEST means
Instructor 1 (B1)	12.00	11.61
Instructor 2 (B2)	12.04	11.81
Instructor 3 (B3)	11.78	12.16

TABLE 4

ANALYSIS OF TOUS PRETEST - POSTTEST (THIRD SUBTEST)

Sources	DF	SS	MS	F RATIO
B	2.	4.69	2.35	0.1687
Error (B)	225.	3128.43	13.90	0.0
A	1.	17.76	17.76	4.0405*
AB	2.	5.08	2.53	0.5775
Error (A)	225.	989.16	4.40	
Total	455	4145.12	9.11	

Group	PRETEST means	POSTTEST means
Instructor 1 (B1)	12.02	12.41
Instructor 2 (B2)	12.40	12.56
Instructor 3 (B3)	12.05	12.68

TABLE 5

ANALYSIS OF WGCTA PRETEST - POSTTEST (TOTAL SCORES)

Sources	DF	SS	MS	F RATIO
B	2.	249.07	124.53	0.8665
Error (B)	129.	18540.20	143.72	0.0
A	1	1096.38	1096.38	30.7773*
AB	2.	176.26	88.13	2.4739
Error (A)	129.	4595.37	35.62	
Total	263.	24657.27	93.75	

Group	PRETEST means	POSTTEST means
Instructor 1 (B1)	72.80	71.56
Instructor 2 (B2)	71.48	67.72
Instructor 3 (B3)	72.70	66.96

TABLE 6

ANALYSIS OF WGCTA PRETEST-POSTTEST (FIRST SUBTEST)

Sources	DF	SS	MS	F RATIO
B	2.	52.06	26.03	2.7590
Error (B)	129.	1217.19	9.44	0.0
A	1.	136.74	136.74	30.1786*
AB	2.	32.75	16.37	3.6134*
Error (A)	129.	584.51	4.53	
Total	263.	2023.26	7.69	

Group	PRETEST means	POSTTEST means
Instructor 1 (B1)	11.68	11.40
Instructor 2 (B2)	11.06	9.81
Instructor 3 (B3)	12.28	10.09

TABLE 7

ANALYSIS OF WGCTA PRETEST-POSTTEST (SECOND SUBTEST)

Sources	DF	SS	MS	F RATIO
B	2.	3.19	1.60	0.1896
Error (B)	129.	1086.21	8.42	0.0
A	1.	50.09	50.09	15.4791*
AB	2.	1.93	0.96	0.2975
Error (A)	129.	417.48	3.24	
Total	263.	1558.91	5.93	

Group	PRETEST means	POSTTEST means
Instructor 1 (B1)	12.96	11.92
Instructor 2 (B2)	12.89	12.22
Instructor 3 (B3)	12.81	11.81

TABLE 8
ANALYSIS OF WGCTA PRETEST-POSTTEST (THIRD SUBTEST)

Sources	DF	SS	MS	F RATIO
B	2.	31.74	15.87	1.1309
Error (B)	129.	1810.09	14.03	0.0
A	1.	181.67	131.67	34.9963*
AB	2.	9.17	4.59	0.8835
Error (A)	129.	669.66	5.19	
Total	263.	2702.33	10.28	

Group	PRETEST means	POSTTEST means
Instructor 1 (B1)	20.60	19.44
Instructor 2 (B2)	19.80	18.33
Instructor 3 (B3)	20.32	18.23

TABLE 9

ANALYSIS OF WGCTA PRETEST-POSTTEST (FOURTH SUBTEST)

Sources	DF	SS	MS	F RATIO
B	2.	23.18	11.59	0.7527
Error (B)	129.	1986.57	15.40	0.0
A	1.	24.24	24.24	3.9836 *
AB	2.	0.72	0.36	0.0590
Error (A)	129.	785.04	6.09	
Total	263.	2819.76	10.72	

Group	PRETEST means	POSTTEST means
Instructor 1 (B1)	16.92	17.72
Instructor 2 (B2)	16.94	17.56
Instructor 3 (B3)	16.42	16.92

TABLE 10

ANALYSIS OF WGCTA PRETEST-POSTTEST (FIFTH SUBTEST)

Sources	DF	SS	MS	F RATIO
B	2.	11.35	5.68	1.0755
Error (B)	129.	680.68	5.27	0.0
A	1.	33.47	33.47	8.6866*
AB	2.	20.49	10.24	2.6587
Error (A)	129.	497.04	3.85	
Total	263.	1243.03	4.73	

Group	PRETEST means	POSTTEST means
Instructor 1 (B1)	10.64	11.08
Instructor 2 (B2)	10.80	9.80
Instructor 3 (B3)	10.87	9.91

TABLE 11

ANALYSIS OF SILANCE PRETEST - POSTTEST (TOTAL SCORES)

Sources	DF	SS	MS	F RATIO
B	2.	2.14	1.07	0.4626
Error (B)	216.	498.43	2.31	0.0
A	1.	0.13	0.13	0.0825
AB	2.	6.11	3.05	1.9619
Error (A)	216.	336.32	1.56	
Total	437.	843.13	1.93	

Group	PRETEST means	POSTTEST means
Instructor 1 (B1)	7.3639	6.7972
Instructor 2 (B2)	6.8742	6.9505
Instructor 3 (B3)	6.8478	6.9122

TABLE 12

ANALYSIS OF SPOTS PRETEST - POSTTEST (TOTAL SCORES)

Sources	DF	SS	MS	F RATIO
B	2.	1266.24	633.12	1.8005
Error (B)	218.	76657.97	351.64	0.0
A	1.	160208.65	160208.65	537.9884*
AB	2.	6710.19	3355.09	11.2666*
Error (A)	218.	64918.66	297.79	
Total	441.	309761.71	702.41	

Group	PRETEST means	POSTTEST means
Instructor 1 (B1)	88.25	112.53
Instructor 2 (B2)	85.44	120.91
Instructor 3 (B3)	76.51	122.62

TABLE 13

ANALYSIS OF DOGMATISM PRETEST - POSTTEST (TOTAL SCORE)

Sources	DF	SX	MS	F RATIO
B	2.	876.50	438.25	0.4230
Error (B)	180.	186481.73	1036.01	0.0
A	1.	0.04	0.0	0.0
AB	2.	178.65	89.33	0.3100
Error (A)	180.	51872.31	288.18	
Total	365.	239409.23	655.92	

Group	PRETEST means	POSTTEST means
Instructor 1 (B1)	135.29	132.74
Instructor 2 (B2)	134.81	134.60
Instructor 3 (B3)	136.94	138.45

TABLE 14

TREATMENT BY SUBJECT ANALYSIS OF TOUS PRETEST - POSTTEST (TOTAL TEST)

Sources	Instructor #1			Instructor #2			Instructor #3		
	DF	SS	MS	DF	SS	MS	DF	SS	MS
Treatment (A)	1.	0.79	0.79	1.	1.82	1.82	1.	218.27	218.27
Error (A)	50.	1380.71	27.61	88.	1753.18	19.92	87.	1496.73	17.20
Total	101.	5767.58		177.	9015.51		175.	6625.98	
F RATIO		F = 0.0288			F = 0.0914			F =12.6875*	
PRETEST Mean		36.73			36.71			35.90	
POSTTEST Mean		36.55			36.91			38.13	

TABLE 15

TREATMENT BY SUBJECT ANALYSIS OF TOUS PRETEST - POSTTEST (FIRST SUBTEST)

Sources	Instructor #1			Instructor #2			Instructor #3		
	DF	SS	MS	DF	SS	MS	DF	SS	MS
Treatment (A)	1.	0.0	0.0	1.	4.72	4.72	1.	65.05	65.05
Error (A)	50.	323.00	6.46	88.	347.78	3.95	87.	337.45	3.87
Total	101.	943.65		177.	1396.28		175.	1129.72	
F RATIO		F = 0.0			F = 1.1955			F = 16.7713*	
PRETEST Mean		12.06			11.67			11.48	
POSTTEST Mean		12.06			12.00			12.69	

TABLE 16

TREATMENT BY SUBJECT ANALYSIS OF WGCTA PRETEST-POSTTEST (TOTAL TEST)

Sources	Instructor #1			Instructor #2			Instructor #3		
	DF	SS	MS	DF	SS	MS	DF	SS	MS
Treatment (A)	1.	19.22	19.22	1.	381.56	381.56	1.	871.85	871.85
Error (A)	24.	730.28	30.43	53.	2310.93	43.60	52.	1554.15	29.89
Total	49.	3873.38		107.	11425.88		105.	9108.94	
F RATIO	F = 0.6316			F = 8.7510*			F = 29.1710*		
PRETEST Mean		72.80			71.5			72.70	
POSTTEST Mean		71.56			67.7			66.96	

TABLE 17

TREATMENT BY SUBJECT ANALYSIS OF WGCTA PRETEST - POSTTEST (FIRST SUBTEST)

Sources	Instructor #1			Instructor #2			Instructor #3		
	DF	SS	MS	DF	SS	MS	DF	SS	MS
Treatment (A)	1.	0.98	0.98	1.	41.56	41.56	1.	126.94	26.94
Error (A)	24.	106.52	4.44	53.	263.94	4.98	52.	214.06	4.12
Total	49.	314.42		107.	834.55		105.	822.23	
F RATIO	F = 0.2208			F = 8.3465*			F = 30.8379*		
PRETEST Mean		11.68			11.1			12.3	
POSTTEST Mean		11.40			9.8			10.1	

TABLE 18

TREATMENT BY SUBJECT ANALYSIS OF SILANCE PRETEST - POSTTEST (TOTAL SCORE)

Sources	Instructor #1			Instructor #2			Instructor #3		
	DF	SS	MS	DF	SS	MS	DF	SS	MS
Treatment(A)	1	5.78	5.78	1	0.27	3.11	1	0.19	0.19
Error(A)	35	49.66	1.42	92	150.25	0.27	89	136.41	1.53
Total	71	87.29		185	436.61	1.63	179	317.09	
F RATIO	F = 4.0737 *			F = 0.1659			F = 0.1219		
PRETEST Mean		7.3639			6.8742			6.8478	
POSTTEST Mean		6.7972			6.9505			6.9122	

TABLE 19

TREATMENT BY SUBJECT ANALYSIS OF SPOTS PRETEST - POSTTEST (TOTAL SCORE)

Sources	Instructor #1			Instructor #2			Instructor #3		
	DF	SS	MS	DF	SS	MS	DF	SS	MS
Treatment(A)	1	11934.23	11934.23	1	58512.91	58512.91	1	97796.54	97796.54
Error(A)	34	9455.77	278.11	92	18013.59	195.80	91	35324.46	388.18
Total	69	38716.34		185	102043.15		183	166791.22	
F RATIO	F = 42.9118*			F = 298.8403*			F = 251.9355*		
PRETEST Mean		87.57			85.44			76.51	
POSTTEST Mean		113.69			120.91			122.62	

TABLE 20

SUMMARY OF PRETEST-POSTTEST RESULTS FOR TOUS

TEST		Total Test	First Subtest	Second Subtest	Third Subtest
TOTAL TEST	F	4.48*	9.05*	0.03	4.04*
	$\bar{X}$ Pre	36.40	11.68	11.93	12.18
	$\bar{X}$ Post	37.30	12.28	11.90	12.57
Instruc. #1	F	0.03	0.00	0.78	1.05
	$\bar{X}$ Pre	36.73	12.06	12.00	12.02
	$\bar{X}$ Post	36.55	12.06	11.61	12.41
Instruc. #2	F	0.091	1.19	0.55	0.23
	$\bar{X}$ Pre	36.71	11.67	12.04	12.40
	$\bar{X}$ Post	36.91	12.00	11.81	12.56
Instruc. #3	F	12.69*	16.77*	1.69	4.17*
	$\bar{X}$ Pre	35.90	11.48	11.78	12.05
	$\bar{X}$ Post	38.13	12.69	12.16	12.68

TABLE 21

SUMMARY OF PRETEST-POSTTEST RESULTS FOR WGCTA

TEST		Total Test	First Subtest	Second Subtest	Third Subtest	Fourth Subtest	Fifth Subtest
TOTAL TEST	F	30.78*	30.18*	15.48*	34.99*	3.98*	8.69*
	$\bar{X}$ Pre	72.20*	11.67	12.87	20.16	16.73	10.80
	$\bar{X}$ Post	68.10	10.23	12.00	18.50	17.33	10.08
Instruc. #1	F	0.63	0.22	3.51	5.26*	1.88	1.29
	$\bar{X}$ Pre	72.80	11.68	12.96	20.60	16.92	10.64
	$\bar{X}$ Post	71.56	11.40	11.92	19.44	17.72	11.08
Instruc. #2	F	8.75*	8.35*	3.38	8.17*	1.69	7.82*
	$\bar{X}$ Pre	71.50	11.10	12.90	19.80	16.94	10.80
	$\bar{X}$ Post	67.70	9.80	12.20	18.30	17.56	9.80
Instruc. #3	F	29.17*	30.84*	10.06*	27.69*	.98	4.74*
	$\bar{X}$ Pre	72.70	$12.3\overset{8}{0}$	12.81	20.32	16.42	10.87
	$\bar{X}$ Post	66.96	$10.1\overset{0}{0}$	11.81	18.23	16.92	9.91

TABLE 22

SUMMARY OF SIGNIFICANT FACTORS FOR PRETESTS-POSTTESTS

(SUMMARY OF TABLES 1 - 21)*

		TOUS			WGCTA						SPOTS
		total	1st	3rd	total	1st	2nd	3rd	4th	5th	
Total test	F(A)	4.5	9.1	4.0	30.8	30.2	15.5	35.0	4.0	8.7	538
	$\bar{X}$(PRE)	36.4	11.7	12.2	72.2	11.7	12.9	20.2	16.7	10.8	82.2
	$\bar{X}$(POST)	37.3	12.3	12.6	68.1	10.2	12.0	18.5	17.3	10.0	120.3
	F(AB)	3.1	3.3	--	--	3.6	--	--	--	--	11.3
Instruc. #1	F(A)	--	--	--	--	--	--	5.3	--	--	42.9
	$\bar{X}$(PRE)	--	--	--	--	--	--	20.6	--	--	87.6
	$\bar{X}$(POST)	--	--	--	--	--	--	19.4	--	--	113.7
Instruc. #2	F	--	--	--	8.8	8.4	--	8.2	--	7.8	298.8
	$\bar{X}$(PRE)	--	--	--	71.5	11.1	--	19.8	--	10.8	85.4
	$\bar{X}$(POST)	--	--	--	67.7	9.8	--	18.3	--	9.8	120.9
Instruc. #3	F	12.7	16.8	4.2	29.2	30.8	10.1	27.7	--	4.7	251.9
	$\bar{X}$(PRE)	35.9	11.5	12.1	72.7	12.3	12.8	20.3	--	10.9	76.5
	$\bar{X}$(POST)	38.1	12.7	12.7	67.9	10.1	11.8	18.3	--	9.9	122.6

* significant at 0.05 level

B. Multiple Regression Analysis for Predicting Student Changes

Appendices N through P include the correlation matrices of the twenty-six variables for each of the four dependent variables. Tables 23 through 34 on pages 118 through 129 summarize the results of the stepwise regression analyses for the four criterion measures. There is negative correlation between the TOUS dependent variable growth scores and dogmatism (cf. Appendix N). The apparent trend of negative correlations between the independent variables (e.g., college physics, college biology, and high school mathematics) with the TOUS and Silance tests as the criterion measures was unexpected. An explanation of such negative trends could be explained by the probable fact that these subjects were taught in a 'traditional' way which led to the development of negative attitudes toward the physical science course. It is not surprising, as the writer proposed earlier, to find a negative relationship between dogmatism and several academic independent variables. These variables include science and English scores on ACT, and high school biology.

For the TOUS test the set of all the twenty-six predictors accounted for 15.42% of the variance. The academic variables, the three instructors, and the ten personal predictors accounted for 5.48%, 6.01%, and 3.93% of the variance respectively. In other words, when this contribution of all twenty-six variables is considered to be 100%, the academic variables, the instructors, and the personal variables accounted for 35.58%, 38.93%, and 25.49% of the total contribution respectively.

The following set of five predictors was found to be significant in increasing R square at the 0.05 level:

1. Instructor #3.
2. Intellectual efficiency.
3. College classification.
4. Instructor #1.
5. Sex.

This set of five predictors accounted for 76.2% of the total contribution using all the twenty-six independent variables. Predictors related to instructors in the above set should not be treated with the same implications as the others.

A student with the following characteristics is most likely to achieve a positive gain on TOUS.

1. Enrollment with Instructor #3 and avoiding enrollment with Instructor #1.
2. High score on Intellectual Efficiency subtest of CPI.
3. Freshman or Sophomore standing.
4. Female.

It is a surprise to see that high school and college science and mathematics backgrounds were not found to be significant in predicting growth scores on TOUS. It is interesting to see that intellectual efficiency as a factor is more important in predicting student change as measured by TOUS than college and high school backgrounds in science and mathematics.

For the WGCTA test the set of all the twenty-six predictors accounted for 18.42% of the variance. The academic predictors, the three instructors, and the ten personal predictors accounted for 10.55%, 1.19%, and 6.68% of the variance respectively. In other words, when the total contribution of all the twenty-six variables is considered to be 100%, academic variables, the three instructors, and personal predictors accounted for 57.28%, 6.46%, and 36.26% of the total contribution respectively.

The following set of four predictors was found to be significant in increasing R square at the 0.05 level:

1. Completion of college physics.
2. Instructor #1.
3. Tolerance.
4. Responsibility.

This set of four predictors accounted for 49.8% of the total contribution using all the twenty-six independent variables. Again, the predictors related to instructors in the above set should be treated with some caution.

It is interesting to note that two personal predictors in addition to Instructor #1 were among this set of four significant predictors. High school and college backgrounds appeared to be insignificant in predicting science and mathematics with the exception of college physics as measured by the growth scores on WGCTA.

A student with the following characteristics is most likely to suffer large loss as measured by WGCTA:

1. Little or no college physics.
2. Enrollment with instructors other than Instructor #1.
3. High score on the Tolerance subtest of CPI.
4. Low score on the Responsibility subtest of CPI.

For the Silance test the set of all the twenty-six predictors accounted for 11.83% of the variance. When the total contribution for all the twenty-six variables is considered to be 100%, the thirteen academic factors, the three instructors, and the personal variables accounted for 57.82%, 18.25%, and 23.92% of the total contribution respectively.

The following set of three variables was found to be significant in increasing R square at the 0.05 level.

1. Course selected to fulfill a requirement or as an elective.
2. Instructor #1.
3. Completion of college physics.

This set of three predictors accounted for 7.16% of the total variance or 60.5% of the total contribution using all the twenty-six independent variables. Predictors related to instructors in the above set should not be treated with the same implications as the others.

A student with the following characteristics is most likely to achieve positive growth on Silance:

1. Taking the physical science course on an elective basis.
2. Avoiding enrollment with Instructor #1.
3. Completion of little or no college physics.

The negative relationship between taking college physics and gaining in the attitude of students towards the physical science course might be explained by arguing that college physics was taught in a 'traditional' way which led to the development of negative attitudes toward physical science courses. It was expected, of course, that taking the course on an elective basis would be the most significant predictor in determining positive student attitudes toward the course under consideration.

For the SPOTS test the set of all the twenty-six independent variables accounted for 22.0% of the variance. The thirteen academic variables, the three instructors, and the ten personal variables accounted for 5.37%, 10.82%, and 5.81% of the variance respectively. In other words, when the total contribution of all the twenty-six variables is considered to be 100%, the academic variables, the three instructors, and the ten personal variables accounted for 24.41%, 49.18%, and 26.41% of the total contribution respectively.

The following set of eight variables was found to be significant in increasing R square at the 0.05 level.

1. Instructor #3.
2. Instructor #1.
3. Completion of college physics.
4. Sex.
5. Dogmatism.
6. Flexibility.
7. Self-presence.
8. Achievement via conformance.

This set of eight factors accounted for 19.48% of the total variance or 88.5% of the total contribution, using all the twenty-six independent variables. As previously, predictors related to instructors should not be treated with same implications as the others. It is interesting to note that college physics and sex are the only significant factors among the thirteen academic variables.

A student with the following characteristics is most likely to achieve positive growth on SPOTS:

1. Enrollment with Instructor #3 and avoidance of enrollment with Instructor #1.
2. Completion of college physics.

3. Female.
4. Dogmatic.
5. Flexible.
6. High score on Self Presence subtest of CPI.
7. High score on Achievement via conformance subtest of CPI.

Variables found to be insignificant for the four dependent variables at the five percent level were:

1. The number of units of high school mathematics.
2. The number of semesters of college mathematics.
3. The number of units of high school biology.
4. The number of units of college biology.
5. The number of units of high school physics.
6. High school rank.
7. Capacity for status.
8. Achievement via independence.
9. Achievement via conformity.
10. Mathematics scores on ACT.
11. English scores on ACT.
12. Science scores on ACT.
13. Self-Acceptance.

In the prediction of WGCTA, TOUS, Silance, and SPOTS growth scores in this study, only 5.48%, 10.55%, 6.84%, and 5.37% respectively of the variances were accounted for by a selected 'traditional' set of thirteen academic variables. These figures are equivalent to 35.5%, 57.28%, 57.82%, and 24.41% respectively of the total contribution obtained by using all the twenty-six variables. These 'small' percentages suggest that there should be additional predictors to those selected and identified as academic factors. The existence of the effect of several personal variables in predicting the scores on the four criterion measures implies that there are abilities which are significant in predicting the results of academic endeavor other than those measured by standardized achievement and intelligence tests. College physics appeared to be a significant predictor for WGCTA, Silance, and SPOTS. Table 32 on page 127 summarizes the significant factors in predicting instructional outcomes as measured by the growth scores on TOUS, WGCTA, Silance, and SPOTS. The 0.05 level of significance was chosen for all analyses.

Allowing all the twenty-six predictors to enter freely in the stepwise program, academic variables - namely, high school courses in physics, biology, and mathematics; college courses in mathematics and biology; and scores on ACT - were not among the significant predictors on any of the four criteria. At the same time, personal predictors - namely, intellectual efficiency for predicting growth scores on TOUS; tolerance and responsibility for predicting growth scores on WGCTA; dogmatism, flexibility, and achievement via conformity, for predicting growth scores on SPOTS - were among the significant predictors.

TABLE 23

SUMMARY OF STEPWISE REGRESSION FOR TOUS GROWTH SCORES

STEP #1 - ALL VARIABLES INCLUDED

Step #	Variable	Multiple		Increase In RSQ	F Value
		R	RSQ		
1	INSTO3 27	0.2073	0.0430	0.0430	9.0233*
2	IEFFCN 18	0.2654	0.0704	0.0274	5.9058*
3	CLASSF 8	0.3002	0.0901	0.0197	4.3108*
4	INSTO1 25	0.3220	0.1037	0.0136	2.9965*
5	SEX-MF 13	0.3427	0.1175	0.0138	3.0774*
6	HS RAN 1	0.3528	0.1245	0.0070	1.5620
7	CSTATS 23	0.3582	0.1283	0.0039	0.8668
8	C PHY 2	0.3625	0.1314	0.0031	0.6887
9	SPRSNC 22	0.3666	0.1344	0.0030	0.6636
10	RESPON 20	0.3718	0.1382	0.0038	0.8496
11	H MATH 5	0.3754	0.1409	0.0027	0.6090
12	SACCEP 21	0.3780	0.1429	0.0019	0.4300
13	TOLRNC 16	0.3814	0.1455	0.0026	0.5698
14	AVINDP 17	0.3856	0.1487	0.0032	0.7167
15	H PHYS 3	0.3873	0.1500	0.0013	0.2820
16	C BIOL 10	0.3886	0.1510	0.0011	0.2329
17	RE ELV 9	0.3898	0.1519	0.0009	0.1964
18	FLEXBT 15	0.3910	0.1529	0.0009	0.2009
19	DGMTSM 14	0.3916	0.1533	0.0005	0.0973
20	EN ACT 12	0.3921	0.1537	0.0004	0.0840
21	H BIOL 11	0.3925	0.1540	0.0003	0.0665
22	SC ACT 6	0.3926	0.1542	0.0001	0.0293
23	MT ACT 7	0.3927	0.1542	0.0000	0.0089
24	AVCONF 19	0.3927	0.1542	0.0000	0.0030
25	C MATH 4	0.3927	0.1542	0.0000	0.0028

TABLE 24

SUMMARY OF STEPWISE REGRESSION FOR TOUS GROWTH TOTAL SCORE
STEP #2 - FORCING ACADEMIC AND INSTRUCTOR VARIABLES

Step #	Variable	Multiple R	Multiple RSQ	Increase In RSQ	F Value
1	SEX-MF 13	0.1639	0.0269	0.0269	5.5485 *
2	CLASSF 8	0.1871	0.0350	0.0081	1.6857
3	H MATH 5	0.2098	0.0440	0.0090	1.8752
4	HS RAN 1	0.2190	0.0479	0.0039	0.8202
5	RE ELV 9	0.2264	0.0513	0.0033	0.6855
6	H PHYS 3	0.2295	0.0527	0.0014	0.2961
7	EN ACT 12	0.2324	0.0540	0.0013	0.2730
8	MT ACT 7	0.2330	0.0543	0.0003	0.0553
9	C PHY 2	0.2333	0.0544	0.0001	0.0280
10	C MATH 4	0.2338	0.0547	0.0003	0.0537
11	H BIOL 11	0.2339	0.0547	0.0001	0.0105
12	C BIOL 10	0.2340	0.0548	0.0000	0.0077
13	SC ACT 6	0.2340	0.0548	0.0000	0.0007
14	INST03 27	0.3132	0.0981	0.0433	9.0261 *
15	INST01 25	0.3389	0.1149	0.0168	3.5474 *
16	IEFFCN 18	0.3655	0.1336	0.0187	4.0230 *
17	CSTATS 23	0.3707	0.1375	0.0039	0.8261
18	SPRSNC 22	0.3754	0.1409	0.0035	0.7454
19	RESPON 20	0.3794	0.1439	0.0030	0.6368
20	SACCEP 21	0.3830	0.1467	0.0028	0.5948
21	TOLRNC 16	0.3862	0.1491	0.0024	0.5190
22	AVINDP 17	0.3911	0.1530	0.0038	0.8173
23	FLEXBT 15	0.3921	0.1537	0.0007	0.1526
24	DGMTSM 14	0.3927	0.1542	0.0005	0.1060
25	AVCONF 19	0.3927	0.1542	0.0000	0.0032

TABLE 25

SUMMARY OF STEPWISE REGRESSION FOR WGCTA GROWTH SCORES

STEP #1 - ALL VARIABLES INCLUDED

Step #	Variable	Multiple R	Multiple RSQ	Increase In RSQ	F Value
1	C PHY 2	0.1753	0.0307	0.0307	3.2651 *
2	INST01 25	0.2350	0.0552	0.0245	2.6426 *
3	TOLRNC 16	0.2666	0.0711	0.0159	1.7275 *
4	RESPON 20	0.3032	0.0919	0.0208	2.2925 *
5	MT ACT 7	0.3328	0.1107	0.0188	2.0965
6	INST02 26	0.3471	0.1204	0.0097	1.0811
7	HS RAN 1	0.3590	0.1289	0.0085	0.9419
8	C MATH 4	0.3692	0.1363	0.0074	0.8271
9	H MATH 5	0.3805	0.1447	0.0084	0.9330
10	AVINDP 17	0.3878	0.1504	0.0057	0.6262
11	FLEXBT 15	0.4003	0.1602	0.0098	1.0886
12	C BIOL 10	0.4055	0.1644	0.0042	0.4590
13	SC ACT 6	0.4110	0.1689	0.0045	0.4921
14	SPRSNC 22	0.4140	0.1714	0.0025	0.2760
15	CSTATS 23	0.4188	0.1754	0.0039	0.4235
16	CLASSF 8	0.4210	0.1773	0.0019	0.2023
17	DGMTSM 14	0.4234	0.1793	0.0020	0.2129
18	SACCEP 21	0.4255	0.1810	0.0018	0.1858
19	SEX-MF 13	0.4270	0.1823	0.0013	0.1316
20	AVCONF 19	0.4280	0.1832	0.0009	0.0901
21	H PHYS 3	0.4288	0.1839	0.0007	0.0749
22	IEFFCN 18	0.4291	0.1842	0.0003	0.0262
23	RE ELV 9	0.4292	0.1842	0.0000	0.0041
24	H BIOL 11	0.4292	0.1842	0.0000	0.0015
25	EN ACT 12	0.4292	0.1842	0.0000	0.0014

TABLE 26

SUMMARY OF STEPWISE REGRESSION FOR WGCTA GROWTH TOTAL SCORE STEP #2 - FORCING ACADEMIC AND INSTRUCTOR VARIABLES

Step #	Variable	Multiple R	RSQ	Increase In RSQ	F Value
1	C PHY 2	0.1753	0.0307	0.0307	3.2651*
2	MT ACT 7	0.2182	0.0476	0.0169	1.8094
3	HS RAN 1	0.2521	0.0636	0.0159	1.7184
4	C MATH 4	0.2730	0.0745	0.0110	1.1873
5	H MATH 5	0.2895	0.0838	0.0093	1.0014
6	CLASSF 9	0.3102	0.0962	0.0124	1.3443
7	C BIOL 10	0.3181	0.1012	0.0050	0.5364
8	SEX-MF 13	0.3228	0.1042	0.0030	0.3218
9	SC ACT 6	0.3240	0.1050	0.0008	0.0856
10	EN ACT 12	0.3247	0.1054	0.0004	0.0466
11	H PHYS 3	0.3247	0.1054	0.0000	0.0015
12	H BIOL 11	0.3247	0.1055	0.0000	0.0010
13	RE ELV 9	0.3247	0.1055	0.0000	0.0002
14	INST01 25	0.3408	0.1162	0.0107	1.0898
15	INST02 26	0.3427	0.1174	0.0013	0.1289
16	TOLRNC 16	0.3787	0.1434	0.0259	2.6658*
17	RESPON 20	0.3966	0.1573	0.0139	1.4322
18	AVINDP 17	0.4047	0.1638	0.0065	0.6726
19	FLEXBT 15	0.4177	0.1745	0.0107	1.0981
20	DGMTSM 14	0.4209	0.1772	0.0027	0.2765
21	SPRSNC 22	0.4235	0.1793	0.0022	0.2190
22	CSTATS 23	0.4269	0.1822	0.0029	0.2876
23	SACCEP 21	0.4279	0.1831	0.0009	0.0901
24	AVCONF 19	0.4290	0.1840	0.0009	0.0874
25	IEFFCN 18	0.4292	0.1842	0.0002	0.0229

TABLE 27

SUMMARY OF STEPWISE REGRESSION FOR SILANCE GROWTH SCORES

STEP #1 - ALL VARIABLES INCLUDED

Step #	Variable	Multiple R	RSQ	Increase In RSQ	F Value
1	RE ELV 9	0.1805	0.0326	0.0326	5.6232*
2	INSTO1 25	0.2397	0.0575	0.0249	4.3825*
3	C PHY 2	0.2676	0.0716	0.0142	2.5178*
4	H MATH 5	0.2760	0.0762	0.0046	0.8123
5	H PHYS 3	0.2871	0.0825	0.0063	1.1109
6	IEFFCN 18	0.2927	0.0856	0.0032	0.5659
7	TOLRNC 16	0.3018	0.0911	0.0054	0.9580
8	MT ACT 7	0.3065	0.0939	0.0029	0.5106
9	RESPON 20	0.3123	0.0975	0.0036	0.6311
10	FLEXBT 15	0.3176	0.1009	0.0033	0.5842
11	EN ACT 12	0.3236	0.1047	0.0039	0.6812
12	DGMTSM 14	0.3281	0.1076	0.0029	0.5074
13	C BIOL 10	0.3323	0.1104	0.0028	0.4858
14	AVCONF 19	0.3343	0.1118	0.0013	0.2319
15	SACCEP 21	0.3366	0.1133	0.0015	0.2612
16	CLASSF 8	0.3387	0.1147	0.0014	0.2424
17	SC ACT 6	0.3405	0.1159	0.0012	0.2087
18	H BIOL 11	0.3415	0.1166	0.0007	0.1236
19	CSTATS 23	0.3422	0.1171	0.0004	0.0730
20	HS RAN 1	0.3428	0.1175	0.0005	0.0766
21	SEX-MF 13	0.3436	0.1181	0.0005	0.0900
22	C MATH 4	0.3438	0.1182	0.0001	0.0205
23	AVINDP 17	0.3439	0.1182	0.0001	0.0089
24	INSTO2 26	0.3439	0.1183	0.0001	0.0083
25	SPRSNC 22	0.3440	0.1183	0.0000	0.0018

TABLE 28

SUMMARY OF STEPWISE REGRESSION FOR SILANCE GROWTH TOTAL SCORE STEP #2 - FORCING ACADEMIC AND INSTRUCTOR VARIABLES

Step #	Variable	Multiple		Increase	F Value
		R	RSQ	In RSQ	
1	RE ELV 9	0.1805	0.0326	0.0326	5.6232*
2	C PHY 2	0.2148	0.0461	0.0136	2.3588*
3	H MATH 5	0.2280	0.0520	0.0058	1.0159
4	H PHYS 3	0.2457	0.0604	0.0084	1.4699
5	EN ACT 12	0.2503	0.0627	0.0023	0.3946
6	CLASSF 8	0.2527	0.0638	0.0012	0.2064
7	C BIOL 10	0.2578	0.0665	0.0026	0.4538
8	MT ACT 7	0.2593	0.0672	0.0008	0.1308
9	SEX-MF 13	0.2599	0.0675	0.0003	0.0478
10	SC ACT 6	0.2608	0.0680	0.0005	0.0815
11	HS RAN 1	0.2612	0.0682	0.0002	0.0405
12	H BIOL 11	0.2614	0.0683	0.0001	0.0121
13	C MATH 4	0.2615	0.0684	0.0001	0.0094
14	INST01 25	0.2996	0.0898	0.0214	3.6219*
15	INST02 26	0.3000	0.0900	0.0002	0.0381
16	RESPON 20	0.3087	0.0953	0.0053	0.8849
17	FLEXBT 15	0.3172	0.1006	0.0053	0.8948
18	TOLRNC 16	0.3262	0.1064	0.0058	0.9712
19	IEFFCN 18	0.3316	0.1099	0.0036	0.5943
20	DGMTSM 14	0.3362	0.1130	0.0031	0.5109
21	AVCONF 19	0.3395	0.1152	0.0022	0.3717
22	SACCEP 21	0.3430	0.1176	0.0024	0.3958
23	CSTATS 23	0.3439	0.1182	0.0006	0.1014
24	AVINDP 17	0.3439	0.1183	0.0001	0.0084
25	SPRSNC 22	0.3440	0.1183	0.0000	0.0018

TABLE 29

SUMMARY OF STEPWISE REGRESSION FOR SPOTS GROWTH SCORES

STEP #1 - ALL VARIABLES INCLUDED

Step #	Variable	Multiple R	Multiple RSQ	Increase In RSQ	F Value
1	INST03 27	0.2987	0.0892	0.0892	16.6508*
2	INST01 25	0.3268	0.1068	0.0176	3.3287*
3	C PHY 2	0.3484	0.1214	0.0146	2.7830*
4	SEX-MF 13	0.3724	0.1387	0.0173	3.3611*
5	DGMTSM 14	0.3859	0.1489	0.0102	1.9955*
6	FLEXBT 15	0.4030	0.1624	0.0135	2.6632*
7	CSTATS 23	0.4128	0.1704	0.0079	1.5689*
8	SPRSNC 22	0.4312	0.1859	0.0156	3.1139*
9	AVCONF 19	0.4414	0.1948	0.0089	1.7881*
10	H BIOL 11	0.4509	0.2033	0.0085	1.7180
11	H MATH 5	0.4551	0.2071	0.0038	0.7720
12	H PHYS 3	0.4590	0.2107	0.0035	0.7116
13	SACCEP 21	0.4628	0.2142	0.0035	0.6999
14	HS RAN 1	0.4654	0.2166	0.0024	0.4858
15	EN ACT 12	0.4662	0.2173	0.0007	0.1495
16	RESPON 20	0.4672	0.2182	0.0009	0.1788
17	RE ELV 9	0.4683	0.2193	0.0011	0.2094
18	IEFFCN 18	0.4687	0.2197	0.0004	0.0780
19	CLASSF 8	0.4689	0.2198	0.0002	0.0295
20	SC ACT 6	0.4689	0.2199	0.0000	0.0064
21	MT ACT 7	0.4690	0.2200	0.0001	0.0155
22	C BIOL 10	0.4690	0.2200	0.0000	0.0039
23	TOLRNC 16	0.4690	0.2200	0.0000	0.0018
24	AVINDP 17	0.4690	0.2200	0.0000	0.0004
25	C MATH 4	0.4690	0.2200	0.0000	0.0001

TABLE 30

SUMMARY OF STEPWISE REGRESSION FOR SPOTS GROWTH TOTAL SCORE

STEP #2 - FORCING ACADEMIC AND INSTRUCTOR VARIABLES

Step #	Variable	Multiple R	Multiple RSQ	Increase In RSQ	F Value
1	H BIOL 11	0.1294	0.0167	0.0167	2.8929*
2	SEX-MF 13	0.1654	0.0274	0.0106	1.8483*
3	C PHY 2	0.1947	0.0379	0.0105	1.8403*
4	HS RAN 1	0.2205	0.0486	0.0107	1.8793*
5	H MATH 5	0.2221	0.0493	0.0007	0.1266
6	MT ACT 7	0.2254	0.0508	0.0015	0.2546
7	SC ACT 6	0.2284	0.0522	0.0014	0.2368
8	H PHYS 3	0.2302	0.0530	0.0008	0.1402
9	C MATH 4	0.2306	0.0532	0.0002	0.0311
10	CLASSF 8	0.2310	0.0534	0.0002	0.0329
11	C BIOL 10	0.2315	0.0536	0.0002	0.0352
12	RE ELV 9	0.2317	0.0537	0.0001	0.0170
13	EN ACT 12	0.2317	0.0537	0.0000	0.0027
14	INST03 27	0.3759	0.1413	0.0876	16.0245*
15	INST01 25	0.4023	0.1619	0.0206	3.8260*
16	DGMTSM 14	0.4134	0.1709	0.0090	1.6808
17	FLEXBT 15	0.4266	0.1820	0.0111	2.0902*
18	CSTATS 23	0.4347	0.1889	0.0070	1.3138
19	SPRSNC 22	0.4505	0.2030	0.0140	2.6749*
20	AVCONF 19	0.4621	0.2136	0.0106	2.0342*
21	SACCEP 21	0.4671	0.2182	0.0046	0.8845
22	RESPON 20	0.4685	0.2195	0.0013	0.2540
23	IEFFCN 18	0.4690	0.2200	0.0005	0.0897
24	TOLRNC 16	0.4690	0.2200	0.0000	0.0018
25	AVINDP 17	0.4690	0.2200	0.0000	0.0004

TABLE 31

ANALYSIS OF VARIANCE FOR ALL INDEPENDENT VARIABLES AMONG INSTRUCTORS

Source	VAR.	MS	F	Source	VAR.	MS	F
G	HS RAN 1	311.7	2.0	G	EN ACT 12	0.9	0.1
W		159.7		W		10.8	
G	C PHY 2	8.5	1.4	G	SEX-MF 13	0.2	0.8
W		6.0		W		0.2	
G	H PHYS 3	.2	.3	G	DGMTSM 14	315.3	0.6
W		.5		W		521.1	
G	C MATH 4	49.2	1.8	G	FLEXBT 15	15.9	1.3
W		27.4		W		12.6	
G	H MATH 5	0.9	1.2	G	TOLRNC 16	40.1	1.9
W		0.7		W		21.6	
G	SC ACT 6	6.6	0.4	G	AVINDP 17	8.2	0.6
W		18.2		W		14.3	
G	MT ACT 7	31.8	1.4	G	IEFFCN 18	10.5	0.3
W		22.0		W		31.7	
G	CLASSF 8	0.0	0.2	G	AVCONF 19	0.5	0.1
W		0.1		W		21.7	
G	RE ELV 9	0.1	0.7	G	RESPON 20	2.0	0.1
W		0.2		W		19.4	
G	C BIOL 10	5.0	0.4	G	SACCEP 21	5.8	0.4
W		11.5		W		15.5	
G	H BIOL 11	0.1	0.3	G	SPRSNC 22	42.1	1.4
W		0.2		W		30.2	
G				G	CSTATS 23	7.0	0.5
W				W		14.3	

TABLE 32

SUMMARY OF SIGNIFICANT FACTORS IN STEPWISE REGRESSION FOR SILANCE, SPOTS, TOUS, AND WGCTA

Step #	Variable	Multiple		Increase In RSQ	F Value
		R	RSQ		
For SILANCE					
1	RE ELV 9	0.1805	0.0326	0.0326	5.6232
2	INST01 25	0.2397	0.0575	0.0249	4.3825
3	C PHY 2	0.2676	0.0716	0.0142	2.5178
For SATIC					
1	INST03 27	0.2987	0.0892	0.0892	16.6508
2	INST01 25	0.3268	0.1068	0.0176	3.3287
3	C PHY 2	0.3484	0.1214	0.0146	2.7830
4	SEX-MF 13	0.3724	0.1387	0.0173	3.3611
5	DGMTSM 14	0.3859	0.1489	0.0102	1.9955
6	FLEXBT 15	0.4030	0.1624	0.0135	2.6632
7	SPRSNC 22	0.4312	0.1859	0.0156	3.1139
8	AVCONF 19	0.4414	0.1948	0.0089	1.7881
For TOUS					
1	INST03 27	0.2073	0.0430	0.0430	9.0233
2	IEFFCN 18	0.2654	0.0704	0.0274	5.9058
3	CLASSF 8	0.3002	0.0901	0.0197	4.3108
4	INST01 25	0.3220	0.1037	0.0136	2.9965
5	SEX-MF 13	0.3427	0.1175	0.0138	3.0774
For WGCTA					
1	C PHY 2	0.1753	0.0307	0.0307	3.2651
2	INST01 25	0.2350	0.0552	0.0245	2.6426
3	TOLRNC 16	0.2666	0.0711	0.0159	1.7275
4	RESPON 20	0.3032	0.0919	0.0208	2.2925

TABLE 33

SUMMARY OF SIGNIFICANT FACTORS IN PREDICTING THE FOUR DEPENDENT VARIABLES

TOUS				WGCTA				SILANCE				SPOTS			
VAR.	Step	F	Coeff.	VAR.	Step	F	Coeff.	VAR.	Step	F	Coeff.	VAR.	Step	F	Coeff.
Ins 27	1	9.02	2.67	C.PS.	1	3.27	.50	R-E	1	5.62	.72	Ins 27	1	16.65	16.37
Ieff	2	5.91	.18	Ins 25	2	2.64	3.37	Ins 25	2	4.38	-.77	Ins 25	2	3.33	-10.61
Classf	3	4.31	-2.48	Tol	3	1.73	-.23	C.PS.	3	2.51	-.08	C.PS.	3	2.78	1.24
Ins 25	4	2.99	-1.88	Resp	4	2.29	.298					Sex	4	3.36	7.34
Sex	5	3.07	1.55	MACT	5	2.10	-.296					Dog	5	1.99	.120
												Flex	6	2.66	.92
												S.Pres.	8	3.11	.79
												Av C	9	1.79	.64

TABLE 34

SUMMARY OF CONTRIBUTIONS OF VARIABLES TO TOTAL VARIANCE

Contribution	TOUS		WGCTA		SILANCE		SPOTS	
	% of VAR.	% of total	% of VAR.	% of total	% of VAR.	% of total	% of VAR.	% of total
All Variables	15.42	100.00	18.42	100.00	11.83	100.00	22.00	100.00
Academic	5.48	35.58	10.55	57.28	6.84	57.82	5.37	24.41
Instructor	6.01	38.93	1.19	6.46	2.16	18.25	10.82	49.18
Personality	3.93	25.49	6.68	36.26	2.83	23.93	5.81	26.41
Means	.77		-4.17		0.0006		38.15	
Stand. Dev.	6.09		8.16		1.78		26.74	

Students had the option of selecting any one of the the three instructors. The results on Table 31 indicate that there are no significant initial differences among students enrolled with the three instructors on all independent variables. Type one analysis also indicates that the mean growth from pretest to posttest was not identical for the three instructors.

C. Covariance and Simple Randomized Design for Analyzing the Effect of Personality on Student Changes

The results for the analyses of covariance for *TOUS* and *WGCTA* are presented in Tables 36 through 47 on pages 134 through 145. The results of completely randomized design for *Silance* and *SPOTS* are presented in Tables 48 through 52 on pages 146 through 150. The 0.05 level was used to determine significant differences of adjusted means.

The results indicate:

1. There are no significant differences on the factors of college classification and flexibility on *WGCTA*, *TOUS*, *Silance*, and *SPOTS*.
2. There is significant difference between the open and closed-minded groups on *TOUS* only in favor of the open-minded group.
3. There are significant differences between the students taking the course because it is required and those taking the course on an elective

basis on WGCTA and Silance tests in favor of the elective group.

4. There are no significant differences between the students taking the course because it is required and those who are taking the course on an elective basis on TOUS and SPOTS.
5. There are significant differences among the three instructors of the course on TOUS and SPOTS in favor of instructor #3.
6. There is a significant difference between males and females only on Silance in favor of males.

The results of this study suggest the following positive statements:

1. There are no significant differences between males and females on TOUS, WGCTA, and SPOTS. Since, for the students in this sample, the ACT natural science mean scores for men and women are approximately the same, the results for this sample contradict the idea among students that science courses are more appropriate for boys than for girls.
2. There are no significant differences between upper-classmen and lower-classmen on the four criterion measures, WGCTA, TOUS, Silance, and SPOTS. Since, for the students in this sample, the ACT natural science mean score for Freshmen and Sophomores is lower than the mean score for Juniors and Seniors

by 4.67 points, the findings should encourage students to consider the course under consideration during the Freshman or Sophomore years.

3. There are significant differences between the students taking the course because it is required and those taking it on an elective basis. The posttest results on *WGCTA* and *Silance* tests favor elective group. Since, for the students in this sample, the ACT natural science mean scores for both the required and the elective groups are approximately the same, the results should be relevant for decision-making about course requirements and freedom for students to select their own physical science courses at the University of Illinois.

The summary of the covariance and simple randomized analyses are in Table 25 on page 150.

TABLE 35

CORRELATION BETWEEN PRETEST - POSTTEST FOR INSTRUMENTS USED IN STUDY

TEST	Total	Group	Instru.#1		Instru.#2		Instru.#3	
	r	n	r	n	r	n	r	n
1. TOUS	.56	311	.53	70	.59	123	.60	118
2. WGCTA	.60	132	.62	25	.58	54	.65	53
3. SILANCE	.19	219	-.24	36	.31	93	.14	90
4. SPOTS	.06	220	.29	35	.18	93	.1	217

TABLE 36

ANALYSIS OF COVARIANCE RESULTS FOR TOTAL TEST SCORE ACCORDING TO DOGMATISM ON TOUS

Sources	DF	SS	SP	SSY
Treatments (A)	1	458.04	581.31	737.75
Within (W)	281	11899.38	6945.15	12929.38
Total	282	12357.42	7526.46	13667.12

Sources	Adjusted DF	Adjusted SSX	Adjusted MSY	
Treatments (A)	1	207.24	207.24	
Within (W)	280	8875.79	31.70	
Total	281	9083.03		F = 6.54*

Group	X Means	Y Means	Adjusted Y Means
A (open)	38.09	39.28	38.57
B (closed)	35.54	36.04	36.82

T Value for Adjusted Means = -2.56 *

TABLE 37

ANALYSIS OF COVARIANCE RESULTS FOR TOTAL TEST SCORE ACCORDING TO FLEXIBILITY ON TOUS

Sources	DF	SS	SP	SSY
Treatments (A)	1	198.30	200.13	201.98
Within (W)	218	8680.33	4832.33	9630.25
Total	219	8878.63	5032.47	9832.23

Sources	Adjusted DF	Adjusted SSX	Adjusted MSY
Treatments (A)	1	39.70	39.70
Within (W)	217	6940.09	31.98
Total	218	6979.80	F = 1.24

Group	X Means	Y Means	Adjusted Y Means
A (rigid)	36.07	37.08	37.62
B (flexible)	37.97	39.00	38.48

T Value for Adjusted Means = 1.11

TABLE 38

ANALYSIS OF COVARIANCE RESULTS FOR TOTAL TEST SCORE ACCORDING TO REQUIRED OR ELECTIVE ON TOUS

Sources	DF	SS	SP	SSY
Treatments (A)	1	0.01	-0.09	1.31
Within (W)	309	14147.38	7965.54	14456.28
Total	310	14147.38	7965.45	14457.59

Sources	Adjusted DF	Adjusted SSX	Adjusted MSY
Treatments (A)	1	1.41	1.41
Within (W)	308	9971.36	32.37
Total	309	9972.77	F = 0.04

Group	X Means	Y Means	Adjusted Y Means
A (required)	36.64	37.74	37.74
B (elective)	36.65	37.59	37.59

T Value for Adjusted Means = -0.21

TABLE 39

ANALYSIS OF COVARIANCE RESULTS FOR TOTAL TEST SCORE ACCORDING TO COLLEGE CLASSIFICATION ON TOUS

Sources	DF	SS	SP	SSY
Treatments (A)	1	111.74	31.25	8.74
Within (W)	309	14035.64	7934.20	14448.85
Total	310	14147.38	7965.45	14457.59

Sources	Adjusted DF	Adjusted SSX	Adjusted MSY
Treatments (A)	1	9.04	9.04
Within (W)	308	9963.73	32.35
Total	309	9972.77	F = 0.28

Group	X Means	Y Means	Adjusted Y Means
A (lower class)	36.40	37.63	37.77
B (upper class)	38.14	38.12	37.27

T Value for Adjusted Means = -0.53

TABLE 40

ANALYSIS OF COVARIANCE RESULTS FOR TOTAL TEST SCORE ACCORDING TO COURSE INSTRUCTOR ON TOUS

Sources	DF	SS	SP	SSY
Treatments (A)	2	118.79	-123.62	129.43
Within (W)	308	14028.59	8089.07	14328.16
Total.	310	14147.38	7965.45	14457.59

Sources	Adjusted DF	Adjusted SSX	Adjusted MSY
Treatments (A)	2	308.88	154.44
Within (W)	307	9663.89	31.48
Total	309	9972.77	F = 4.91*

Group	X Means	Y Means	Adjusted Y Means
A(Instructor #1)	37.47	36.77	36.29
B(Instructor #2)	36.88	37.51	37.38
C(Instructor #3)	35.91	38.44	38.87

T Value for Adjusted Means = 1.3, 3.0, 2.1

TABLE 41

ANALYSIS OF COVARIANCE RESULTS FOR TOTAL TEST SCORE ACCORDING TO SEX ON TOUS

Sources	DF	SS	SP	SSY
Treatments (A)	1	26.76	-39.73	58.98
Within (W)	309	14120.62	8005.18	14398.61
Total	310	14147.39	7965.45	14457.59

Sources	Adjusted DF	Adjusted SSX	Adjusted MSY	
Treatments (A)	1	112.41	112.41	
Within (W)	308	9860.37	32.01	
Total	309	9972.77		F = 3.51

Group	X Means	Y Means	Adjusted Y Means
A (male)	37.01	37.16	36.95
B (female)	36.41	38.05	38.18

T Value for Adjusted Means = 1.87

TABLE 42

ANALYSIS OF COVARIANCE RESULTS FOR TOTAL TEST SCORE ACCORDING TO DOGMATISM ON WGCTA

Sources	DF	SS	SP	SSY
Treatments (A)	1.	1647.47	970.08	571.21
Within (W)	124.	8536.88	5731.99	12062.00
Total	125.	10184.36	6702.07	12633.21

Sources	Adjusted DF	Adjusted SSY	Adjusted MSY
Treatments (A)	1.	9.42	9.42
Within (W)	123.	8213.32	66.78
Total	124.	8222.75	F=.1411

Group	X Means	Y Means	Adjusted Y Means
A (open)	75.91	70.28	67.93
B (closed)	68.67	66.02	68.52

T Value for Adjusted Means = 0.3757

TABLE 43

ANALYSIS OF COVARIANCE RESULTS FOR TOTAL TEST SCORE ACCORDING TO FLEXIBILITY ON WGCTA

Sources	DF	SS	SP	SSY
Treatments (A)	1	904.84	595.25	391.59
Within (W)	108	8524.21	5492.45	9408.63
Total	109	9429.05	6087.71	9800.21

Sources	Adjusted DF	Adjusted SSX	Adjusted MSY
Treatments (A)	1	0.15	0.15
Within (W)	107	5869.64	54.86
Total	108	5869.79	F = 0.0027

Group	X Means	Y Means	Adjusted Y Means
A (rigid)	69.13	66.13	68.08
B (flexible)	74.88	69.91	68.16

T Value for Adjusted Means = 0.0522

TABLE 44

ANALYSIS OF COVARIANCE RESULTS FOR TOTAL TEST SCORE ACCORDING TO REQUIRED OR ELECTIVE ON WGCTA

Sources	DF	SS	SP	SSY
Treatments (A)	1	5.97	45.55	347.44
Within (W)	130	10698.66	6963.27	12508.82
Total	131	10704.63	7008.83	12856.27

Sources	Adjusted DF	Adjusted SSX	Adjusted MSY
Treatments (A)	1	290.51	290.51
Within (W)	129	7976.47	61.84
Total	130	8267.26	F = 4.70*

Group	X Means	Y Means	Adjusted Y Means
A (required)	72.08	67.05	67.15
B (elective)	72.54	70.56	70.35

T Value for Adjusted Means = 2.167*

TABLE 45

ANALYSIS OF COVARIANCE RESULTS FOR TOTAL TEST SCORE ACCORDING TO CLASSIFICATION ON WGCTA

Sources	DF	SS	SP	SSY
Treatments (A)	1	306.67	299.40	292.30
Within (W)	130	10397.96	6709.43	12563.96
Total	131	10704.63	7008.83	12856.27

Sources	Adjusted DF	Adjusted SSX	Adjusted MSY
Treatments (A)	1	32.64	32.64
Within (W)	129	8234.61	63.83
Total	130	8267.26	F = 0.51

Group	X Means	Y Means	Adjusted Y Means
A (lower class)	71.61	67.55	67.94
B (upper class)	76.06	71.89	69.41

T Value for Adjusted Means = 0.72

TABLE 46

ANALYSIS OF COVARIANCE RESULTS FOR TOTAL TEST SCORE ACCORDING TO INSTRUCTOR ON WGCTA

Sources	DF	SS	SP	SSY
Treatments (A)	2	49.98	36.41	375.35
Within (W)	129	10654.65	6972.42	12480.92
Total	131	10704.63	7008.83	12856.27

Sources	Adjusted DF	Adjusted SSX	Adjusted MSY
Treatments (A)	2	349.10	174.55
Within (W)	128	7918.16	61.86
Total	130	8267.26	F = 2.82

Group	X Means	Y Means	Adjusted Y Means
A (instructor #1)	72.80	71.56	71.18
B (instructor #2)	71.48	67.72	68.21
C (instructor #3)	72.70	66.96	66.65

T Value for Adjusted Means = -1.60, -2.40, -1.10

TABLE 47

ANALYSIS OF COVARIANCE RESULTS FOR TOTAL TEST SCORE ACCORDING TO SEX ON WGCTA

Sources	DF	SS	SP	SSY
Treatments (A)	1.	10.36	9.65	8.99
Within (W)	130.	10694.27	6999.17	12847.27
Total	131.	10704.63	7008.83	12856.27

Sources	Adjusted DF	Adjusted SSX	Adjusted MSY
Treatments (A)	1.	0.79	0.79
Within (W)	129.	8266.46	64.08
Total	130.	8267.26	F = 0.0124

Group	X Means	Y Means	Adjusted Y Means
A (male)	71.81	67.76	68.03
B (female)	72.41	68.19	68.20

T Value for Adjusted Means = 0.1113

TABLE 48

SIMPLE RANDOMIZED ANALYSIS OF SILANCE POSTTEST SCORES BY DOGMATISM, FLEXIBILITY, AND INSTRUCTOR

Sources	Dogmatism DF	SS	MS	Flexibility DF	SS	MS	Instructor DF	SS	MS
Treatment (A)	1.	1.71	1.71	1.	0.01	0.01	2.	0.61	0.31
Error (A)	214.	423.77	1.98	172.	361.44	2.10	216.	431.29	2.00
Total	215.	425.47	1.98	173.	361.44	2.09	218.	431.90	1.98
F RATIO	F = 0.8622			F = 0.0029			F = 0.1530		
Mean for TR (1)	(open)	7.33		(rigid)	6.88		(Instructor #1)	6.80	
Mean for TR (2)	(closed)	6.89		(flexible)	6.86		(Instructor #2)	6.95	
Mean for TR (3)							(Instructor #3)	6.91	

TABLE 49

SIMPLE RANDOMIZED ANALYSIS OF SILANCE POSTTEST SCORES BY SEX, CLASSIFICATION, AND REQUIRED OR ELECTIVE

Sources	Sex			Classification			Required or Elective		
	DF	SS	MS	DF	SS	MS	DF	SS	MS
Treatment (A)	1.	8.48	8.48	1.	0.23	0.23	1.	13.37	13.37
Error (A)	218.	432.44	1.98	216.	413.02	1.91	217.	418.53	1.92
Total	219.	440.92	2.01	217.	413.25	1.90	218.	431.90	1.98
F RATIO	F = 4.2749 *			F = 0.1207			F = 6.9326 *		
Mean for TR (1)	(male)	7.14		(lower class)	6.92		(required)	6.75	
Mean for TR (2)	(female)	6.74		(upper class)	7.01		(elective)	7.30	

TABLE 50

SIMPLE RANDOMIZED ANALYSIS OF SPOTS POSTSCORES BY DOGMATISM, FLEXIBILITY, AND INSTRUCTOR

Sources	Dogmatism			Flexibility			Instructor		
	DF	SS	MS	DF	SS	MS	DF	SS	MS
Treatment (A)	1.	36.19	36.19	1.	226.40	226.40	2.	2704.33	1352.16
Error (A)	216.	63764.98	295.21	173.	45856.15	265.06	218.	63509.97	291.33
Total	217.	63801.17	294.01	174.	46082.55	264.84	220.	66214.30	300.97
F RATIO	F = 0.1226			F = 0.8541			F = 4.6413 *		
Mean for TR (1)	(open)	118.00		(rigid)	121.08		(Instructor #1)	112.53	
Mean for TR (2)	(closed)	120.49		(flexible)	117.24		(Instructor #2)	120.91	
Mean for TR (3)							(Instructor #3)	122.62	

TABLE 51

SIMPLE RANDOMIZED ANALYSIS OF SPOTS POSTSCORES BY SEX, CLASSIFICATION, AND REQUIRED OR ELECTIVE

Sources	Sex			Classification			Required or Elective		
	DF	SS	MS	DF	SS	MS	DF	SS	MS
Treatment (A)	1.	338.28	338.28	1.	56.47	56.47	1.	52.12	52.12
Error (A)	219.	65876.02	300.80	219.	66157.83	302.09	218.	65985.60	302.69
Total	220.	66214.30	300.97	220.	66214.30	300.97	219.	66037.73	301.54
F RATIO	F = 1.1246			F = 0.1869			F = 0.1722		
Mean for TR (1)	(male)	118.81	(lower class)		120.06		(required)	120.01	
Mean for TR (2)	(female)	121.31	(upper class)		121.53		(elective)	121.08	

TABLE 52

SUMMARY OF THE TESTS FOR DEPENDENT AND SELECTED INDEPENDENT VARIABLES (SUMMARY OF TABLES 36 - 51)

TEST		Dogm.	Flex.	R - E	Classif.	Instruc.	Sex
TOUS	F	6.54*	1.24	0.04	0.28	4.91*	3.51
	DF	1,280	1,217	1,308	1,308	2,307	1,308
WGCTA	F	0.14	0.00	4.70*	0.51	2.82	0.01
	DF	1,123	1,107	1,129	1,129	2,128	1,129
Silance	F	0.8622	0.003	6.93*	0.12	0.15	4.27*
	DF	1,214	1,172	1,217	1,216	2,216	1,218
SPOTS	F	0.12	0.85	0.17	0.19	4.64*	1.12
	DF	1,216	1,173	1,218	1,219	2,218	1,219

* Significant at 0.05 level

TABLE 53

RESULTS OF THE TESTS FOR THE HYPOTHESIS OF HOMOGENEOUS VARIANCE

CRITERION MEASURE	Dogmatism		Flexibility		Req-Elect		Classif.		Instructor		Sex	
	F	DF	F	DF	F	DF	F	DF	F	DF	F	DF
SILANCE	1.9	1, 213	3.0	1, 170	1.3	1, 215	0.2	1, 214	3.5	2, 213	5.7	1, 215
	Retain		Retain		Retain		Retain		Retain		Reject	
SPOTS	.03	1, 214	.71	1, 171	.24	1, 216	.77	1, 217	1.3	2, 215	.002	1, 216
	Retain		Retain		Retain		Retain		Retain		Retain	
TOUS	.69	1, 279	.28	1, 216	.16	1, 307	5.2	1, 307	.70	2, 305	4.1	1, 307
	Retain		Retain		Retain		Reject		Retain		Reject	
WGCTA	6.6	1, 122	2.0	1, 106	.001	1, 128	.10	1, 128	1.4	2, 126	5.0	1, 128
	Reject		Retain		Retain		Retain		Retain		Reject	

CHAPTER V

SUMMARY AND CONCLUSIONS

The main purpose of this study was to investigate relationships between student characteristics (academic as well as personal) and student changes. For the purpose of this study, instructional outcomes are measured by the differences between the postscores and prescores on each of the following four dependent variables:

1. *Test On Understanding Science* (*TOUS*)
2. *Watson-Glaser Critical Thinking Appraisal* (*WGCTA*)
3. *A Scale to Measure Attitude Toward Any School Subject* (*Silance*)
4. *Student Perception Of Teacher Style* (*SPOTS*)

Twenty-six variables were selected as predictors. These independent variables were selected as being potentially significant to student critical thinking, understanding of science, attitude toward the physical science course, and instructional climate. The first thirteen variables are identified as academic factors which represent variables commonly used for predictive studies.

These variables include high school and college backgrounds in science and mathematics, and different subscores on ACT. Three additional variables were introduced to identify the three instructors in the course. The ten personal variables include dogmatism and nine subscales of CPI. The nine scales include flexibility, tolerance, responsibility, achievement via independence, achievement via conformity, self-acceptance, social presence, capacity for status, and intellectual efficiency.

The specific purposes of this study were:

1. To test whether the pretest and posttest mean scores on TOUS, WGCTA, Silance, and SPOTS are significantly different.
2. To determine the degree of relationship of each of the twenty-six independent variables to each of the four dependent variables.
3. To find what increase in predictive accuracy is attained by combining measures of the personal and instructor variables with measures of academic factors in predicting student changes.

The sample used in this study consisted of 471 undergraduates enrolled in the "Thought and Structure" course at the University of Illinois. Data were collected during the first semester of the 1971-1972 academic year.

The results are summarized in the following three major divisions: (a) student changes (b) prediction of student changes, and (c) effect of personality on student changes.

A. Student Changes

The following statements concerning student changes (pretest and posttest analyses) can be made about students enrolled in the "Thought and Structure" course when the five percent level of confidence is selected.

1. There is a significant increase in student understanding of science and scientific process as measured by TOUS.
2. There is a significant decrease in student critical thinking ability as measured by WGCTA (Subscores I, II, III, V).
3. There is a significant increase in student ability to interpret results - an ability measured by WGCTA (Subscore IV).
4. There is no significant growth in positive attitude of students towards the physical science course as measured by Silance.
5. There is a significant increase in positive attitude of students towards open instructional climate as measured by SPOTS.

6. There are significant interactions at the 0.05 level for *TOUS* (Total Test and Subscore I), *WGCTA* (Subscore I), and *SPOTS*. This indicates that the mean growth from pretest to posttest was not identical for the three instructors.

B. Prediction of Student Changes

The following statements can be made concerning prediction of student changes:

1. In the prediction of the growth scores on *TOUS*, *WGCTA*, *Silance*, and *SPOTS* only 5.48%, 10.55%, 6.84%, and 5.37% of the variances were accounted for by the academic factors. The above figures correspond to 35.5%, 57.28%, 57.82%, and 24.41% of the total contributions to the variance using all the twenty-six predictors in predicting the growth scores on *TOUS*, *WGCTA*, *Silance*, and *SPOTS* respectively. The small contributions by the academic factors suggest that there are other predictors which are more significant than the selected 'traditional' set of thirteen variables commonly used in the literature for predictive studies.
2. The variables identified by the three instructors accounted for 38.93%, 6.46%, 18.25%, and 49.18%

of the total contribution to the variance obtained by using all the twenty-six independent variables for TOUS, WGCTA, Silance, and SPOTS respectively.

3. The ten personal variables accounted for 25.49%, 36.26%, 23.93%, and 26.41% of the total contribution to the variance obtained by using all the twenty-six independent variables for TOUS, WGCTA, Silance, and SPOTS respectively. Consequently, the personal variables made a significant contribution in predicting student change in the course under consideration which was originally hypothesized by the investigator.
4. There is an apparent trend of negative correlations between dogmatism and several independent variables that relate to student high school and college backgrounds in science and mathematics. These variables include high school biology, science, and English scores on ACT.
5. One would expect the students judged "closed-minded" by the Dogmatism Scale to have difficulty in overcoming sets of beliefs and to show less growth on the dependent variables. This is shown in Table 39 in the negative correlations between the TOUS growth scores and dogmatism.

6. The existence of the effect of several personal predictors in predicting the growth scores on each of the four criterion measures implies that there are abilities which are significant in predicting the results of academic endeavor other than those measured by standardized achievement and intelligence tests.
7. College physics appeared to be a significant factor in predicting the growth scores on *WGCTA*, *Silance*, and *SPOTS*.
8. Variables found to be insignificant for the four dependent variables at the 0.05 level include: high school backgrounds in physics, biology, and mathematics; completion of courses in college biology and mathematics; science, mathematics, and English scores on ACT; capacity for status, achievement via independence, achievement via conformity, self acceptance; and high school rank.
9. Allowing all the twenty-six predictors to enter freely in the stepwise program, academic variables - namely, high school courses in physics, biology, and mathematics; college courses in mathematics and biology; and scores on ACT - were not among the significant predictors on any of the four

criteria. At the same time, personal predictors - namely, intellectual efficiency for predicting growth scores on TOUS; tolerance and responsibility for predicting growth scores on WGCTA; dogmatism, flexibility, and achievement via conformity for predicting growth scores on SPOTS - were among the significant predictors.

C. Effect of Personality Factors on Instructional Outcomes

The following statements can be made concerning the effect of personality and identification factors on instructional outcomes:

1. There is a significant difference between the open and the closed-minded groups only on growth measured by the TOUS test. The open-minded group scored significantly higher than the closed-minded group.
2. There are no significant differences when college classification and flexibility are considered with growth scores of WGCTA, TOUS, Silance, and SPOTS.
3. There are significant differences on adjusted means between the students taking the course to meet a requirement and those taking the course as a free elective on WGCTA and Silance tests. The elective group scored significantly higher than the required group.

CHAPTER VI

STUDY LIMITATIONS AND RECOMMENDATIONS

Certain limitations in the design of the study can be identified and discussed. For example, no control groups were used in this study. A thorough investigation of a single group may be a logical first step. Such information could provide a valuable foundation for future research involving more than one group. The investigation was further limited to undergraduates enrolled in one course (physical science) at one university (the University of Illinois). There are numerous studies in other areas or for other levels of students.

It is recognized that the above limitations do restrict the generalizability of the results. However, the limitations themselves suggest several possibilities for further research within the areas of student personal characteristics, instructional procedures, and student changes.

It would be of interest to apply the results derived from this study to a sample of students from other institutions. It is reasonable to suspect that the conclusions found here would be valid and applicable to other courses with similar objectives and instructional procedures at other colleges with student populations exhibiting similar means on the independent variables.

It is proposed that additional student growth areas be identified. Expanded evaluation of student growth in the cognitive domain needs to be pursued. The investigator suggests the need for additional instruments capable of detecting changes in students' behaviors with little emphasis on "right" or "wrong" answers. Major emphasis is needed on instruments which enable students to make choices consistent with their own views.

The selected set of predictors accounted only for twelve to twenty-two percent of the variance in student change. This suggests a direction for additional research involving additional and/or different predictors. The significance of factors related to course section in the present study suggests the need for systematic studies to investigate the characteristics and effect of instructors on student changes.

It is suggested that additional studies be made to investigate how and to what extent the reactions toward instructional innovations of the open-minded individuals differ from the reactions of closed-minded individuals. Other studies might also examine whether students with different personal profiles would achieve and grow more with different instructional procedures.

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APPENDICES

APPENDIX A

NOTIFICATION OF GRANT AWARD

Dept. of Health, Education, and Welfare Office of Education Washington, D.C. 20202 NOTIFICATION OF GRANT AWARD	Vendor Number OE- 001892 NIH- 564064
1. Name and Address of Institution The University of Iowa Iowa City, Iowa 52240 PROJECT DIRECTOR: Mr. M.I. Himaya (319) 353-2121	2. Grant # OEG-7-72-0024 (509) 2A. Transaction Number 720E9289 3. Project # 2G038 4. Amount $10,000.00 5. Period of Grant
6. Make Checks Payable To: The University of Iowa	From Through 4-15-72 4-14-73 7. Grant Award Is A. X new B. revision number__

APPENDIX A (CONT'D.)

8. Proposal Title
"Identification of Possible Variables for Predicting Student Success in Physical Science College Courses Designed for Non-Science Majors"

---

9. Scope of Work and/or Special Conditions
THIS GRANT CONSISTS OF:

a. By reference: The above-identified grantee's proposal dated 11-11-71; and grantee's letter dated 4-7-72.

b. By attachment: EXHIBIT A - Special Provisions (2 pages).

EXHIBIT B - OE Form 5245, 9/69, Grant Terms and Conditions for Research Programs (General), (4 pages with two added clauses - total of 6 pages).

c. Cost sharing: This grant is subject to an institutional cost sharing arrangement with an effective date of 7-1-71.

10.	Grant Authority P.L. 89-10, Title IV, Section 2 (a)	APPROP. SYM. 7520292	C. A. N. 22072711

Approved

11. Name of Grants Officer
Henry J. Pratt
(816) 374-2541

12. Date
4-14-72

13. Signature of Authorized Government Official

OE FORM 6030, 9/70 Replaces Edition of 7-70, which is obselete

APPENDIX B

PHILOSOPHY AND OBJECTIVES OF THE "THOUGHT AND STRUCTURE IN PHYSICAL SCIENCE" COURSE AT THE UNIVERSITY OF ILLINOIS

This section includes the aims, philosophy, and objectives of the course called "Thought and Structure in Physical Science" (LAS 140) at the Urbana-Champaign Campus of the University of Illinois, as described by the originators of the course, Professors Sidney Rosen and Robert Revak (1970). This course is offered to non-science majors in the Liberal Arts College at the University of Illinois as an elective to satisfy the general education requirements for graduation. The course is also the physical science part of an experimental course for elementary education majors which combines the content of physical science with the methods of teaching science.

Rosen and Revak feel that science, even in the light of the newer science curricula, has never been defined adequately for educational purposes, especially with regard to a meaningful distinction between science and technology.

Rosen and Revak define science as:

1. The making of conjectures about natural

phenomena that may be made in any manner whatsoever (conjectures is used here to mean guesses, hunches, and intuitive ideas) and attempts to refute such conjectures.

2. The emergence of conjectures which, for no apparent reason, cannot be refuted.
3. The development of emergent conjectures toward a point of crystallization beyond which, by this definition, one is operating within his own particular technology. This activity is what they call a "science way of life" (a term used throughout this discussion).

It seems clear, then, that it is in the third stage that the gathering of evidence begins to have meaning. This evidence is utilized to develop a non-refutable conjecture toward a theory that will support generalization and prediction. Since this definition seems to be a departure from the usual definitions of science, it would be reasonable to get students to verbalize their perceptions regarding various physical phenomena. Thus one might begin by determining the frame of reference from which any student might be operating. Hopefully, in this way, students would begin to develop some criteria for the validity of their own ideas. This method calls for a high level of contribution by both teacher and students.

To live comfortably with science, it is necessary to live with a dynamically changing system of concepts; that is, it is necessary to live with enough conservatism to resist the easy abandonment of concepts, but enough flexibility to be able, when necessary, to "switch rather than fight." Ideally, then, a science course for the non-science majors ought to demonstrate to the student what has been called a "science way of life." This implies the following intellectual habits; living comfortably with change; having open-mindedness and tolerance of belief systems other than one's own; developing criteria for the validity of ideas and applying them to one's own belief systems; and, especially for those who are preparing to teach, possessing an awareness and appreciation of the many differing belief systems of students.

If we accept the proposition that an individual's perception of a particular phenomenon differs, let us say, from the textbook, then the first goal of the physical science course is to get the student to examine such differences in the light of evidence that can or cannot be explained. It is assumed that this skill is learned best when the student understands his own point of view and learns to evaluate it. The educated student is assumed to be the one who has a tolerance for a variety of explanations and yet is aware of the possible criteria for an adequate explanation. Nevertheless, the physical sciences have been taught, traditionally, in terms of solving problems by substitution in appropriate formulas and application of other mathematical techniques. For the purpose of general education, and especially for those students destined to become teachers, such a practice leaves much to be desired. Thus, the University of Illinois course attempts to get the students to operate in those early stages of scientific thinking that precede crystallization.

It may seem trite to say that college education should involve an honest examination of one's own beliefs, an honest examination of scholarly opinions, a resulting shift of one's own beliefs, and the selection and organization of evidence into arguments. How often do teachers at any level seek out the student's own belief system and attempt to engage him in its defense? We have to remember that the advancement of knowledge and scholarship proceeds from an honest comparison of conflicting views in the face of evidence, reason, and human judgment.

What is suggested here is that the physical science course must be based to a great extent upon creating conflicting views for the student, causing what might be called "the generation of dissonance" (Festinger, 1957). Consequently, much of the course must be built around frequent "brain-storming" sessions, which involve the expression and recognition of dissonance, and from which may spring a basis for re-thinking.

If critical thinking is emphasized in a physical science course for non-science majors, it seems reasonable to hope that the simultaneous extension of such thinking into the science methods course would prepare the ground for a pedagogy that promotes critical thinking in the classroom. Therefore, an important part of the science methods course ought to be exploring how a student's intuitive view of the world can change.

Thus, if the student in the course is being encouraged to express his or her beliefs about the physical world and to defend those beliefs via a reasonable argument, one can hope that any major rigidity in this student can be loosened. College students often forget why they have changed; accidental fringe interactions within their own belief systems pass almost unnoticed. Any change of view that is made in terms of acquiescence to authority, but without personal conviction, is clearly not a change of any educational value.

The staff of the experimental course is concerned with examining how well the student can handle his own viewpoint concerning a physical phenomenon; on this ability the student is usually graded. The answer choices provided in the examination would allow the student to defend a choice most consistent with his own view. Thus, instead of a text-book "right" or "wrong" answer, the student has a choice of answers, some of which may more easily be defended by a reasonable argument than others. The student may find that in order to plan a defense, he will have to add certain assumptions to the statement of the problem - which he is permitted to do. Each problem might contain a part which asks the student to give the rationale for rejecting one of the answer choices. In short, the staff tries to move the student away from the hidebound tradition of the single, absolute, correct answer to a problem (to which he has been generally conditioned by previous education) and towards the more realistic practice of decision-making by setting criteria for the validity of ideas. The questions are often designed to allow practice in the divergent production of thought. This practice will get the student involved in the make-up of the problem by allowing him not only to set its constraints, but to operate within assumptions of his own which may lie in relationship to the setting of the problem.

Staff members are not really concerned with teaching "their own brand of physical science" as much as they are with examining what Polyani calls "personal knowledge," Although the staff realizes that the students will acquire some familiarity with "their brand", they are concerned with nature of evidence as related to each student's conceptual view. The staff members judge the growth of an individual in terms of that individual's ability to cope with problems, to formulate appropriate questions, and to evaluate alternatives. Competence in the dynamics of learning and the use of knowledge for making rational decisions about problems form the basis for testing. There is less emphasis upon grades as an indicator of one's competitive ability, and more emphasis upon generating diversity.

APPENDIX C

DEFINITIONS AND CHARACTERISTICS FREQUENTLY ASSOCIATED WITH HIGH AND LOW SCORES ON EACH MEASURE OF THE NINE SUBSCALES OF CPI

TABLE 54

DEFINITIONS AND CHARACTERISTICS FREQUENTLY ASSOCIATED WITH HIGH AND LOW SCORES ON EACH MEASURE OF THE NINE SUBSCALES OF CPI

HIGH SCORERS	SCALE AND PURPOSE	LOW SCORER
Tend to be seen as:		Tend to be seen as:
Insightful, informal, adventurous, confident, humorous, rebellious, idealistic, assertive, and egoistic; as being sarcastic and cynical; and as highly concerned with personal pleasure and diversion.	Fx (flexibility) To indicate the degree of flexibility and adaptability of a person's thinking and social behavior.	Deliberate, cautious, worrying, industrious, guarded, mannerly, methodical, and rigid; being overly deferential to authority, custom, and tradition.
Enterprising, informal, quick, tolerant, clear-thinking, and resourceful; as being intellectually able and verbally fluent; and as having broad and varied interests.	To (tolerance) To identify persons with permissive, accepting, and non-judgemental social beliefs and attitudes.	Suspicious, narrow, wary, and retiring; as being passive and overly judgemental in attitude; and as disbelieving and distrustful in personal and social outlook.

TABLE 54 (CONT'D.)

HIGH SCORERS	SCALE AND PURPOSE	LOW SCORER
Tend to be seen as:		Tend to be seen as:
Efficient, clear-thinking, capable, intelligent, progressive, planful, thorough, and resourceful; as being alert and well-informed; and as placing a high value on cognitive and intellectual matters.	Ie (intellectual efficiency) To indicate the degree of personal and intellectual efficiency which the individual has attained.	Cautious, confused, easygoing, defensive, shallow, and unambitious; as being conventional and stereotyped in thinking; and as lacking in self-direction and self-discipline.
Capable, co-operative, efficient, organized, responsible, stable, and sincere; as being persistent and industrious; and as valuing intellectual activity and intellectual achievement.	Ac (achievement via conformance) To identify those factors of interest and motivation which facilitate achievement in any setting where autonomy and independence are negative behaviors.	Coarse, stubborn, aloof, awkward, insecure, and opinionated; as easily disorganized under stress or pressures to conform; and as pessimistic about their occupational futures.
Intelligent, outspoken, sharp-witted, demanding, aggressive, and self-centered; as being persuasive and verbally fluent; and as possessing self-confidence and self-assurance.	Sa (self-acceptance) To assess factors such as sense of personal worth, self-acceptance, and capacity for independent thinking and action.	Methodical, conservative, dependable, conventional, easygoing, and quiet; as self-abasing and given to feeling of guilt and self-blame; and as being passive in action and narrow in interests.

TABLE 54 (CONT'D.)

HIGH SCORERS Tend to be seen as:	SCALE AND PURPOSE	LOW SCORERS Tend to be seen as:
Mature, forceful, strong, dominant, demanding, and foresighted; as being independent and self-reliant, and as having superior intellectual ability and judgment.	Ai (achievement via independence) To identify those factors of interest and motivation which facilitate achievement in any setting where autonomy and independence are positive behaviors.	Inhibited, anxious, cautious, dissatisfied, dull, and wary; as being submissive and compliant before authority; and as lacking self-insight and self-understanding.
Ambitious, active, forceful, insightful, resourceful, and versatile; as being ascendant and self-seeking; effective in communication; and as having personal scope and breadth of interests.	Cs (capacity for status) To serve as an index of an individual's capacity for status (not his actual or achieved status). The scale attempts to measure the personal qualities and attributes which underlie the lead to status.	Apathetic, shy, conventional, dull, mild, simple, and slow; as being stereo-typed in thinking; restricted in outlook and interests; and as being uneasy and awkward in new and unfamiliar social situations.
Clever, enthusiastic, imaginative, quick, informal, spontaneous, and talkative; as being active and vigorous; and as having an expressive, ebullient nature.	Sp (social presence) To assess factors such as poise, spontaneity, and self-confidence in personal and social interaction.	Deliberate, moderate, self-restrained; as uncertain in decision; and as being unoriginal and literal in thinking and judging.

TABLE 54 (CONT'D.)

HIGH SCORERS	SCALE AND PURPOSE	LOW SCORERS
Tend to be seen as:		Tend to be seen as:
Planful, responsible, thorough, progressive, capable, dignified, and independent; as being conscientious and dependable; resourceful and efficient; and as being alert to ethical and moral issues.	Re (responsibility) To identify persons of conscientious, responsible, and dependable disposition and temperament.	Immature, moody, lazy, awkward, changeable, and disbelieving; as being influenced by personal bias, spite, and dogmatism; and as undercontrolled and impulsive in behavior.

APPENDIX D

MEAN SCORE OF INSTRUMENTS USED IN STUDY

TABLE 55

MEAN SCORE OF INSTRUMENTS USED IN STUDY

TEST	SUB. TEST	# ITEM	PRE # STS.	PRE MEAN SCORE	POST # STS.	POST MEAN SCORE
TOUS	T	60	471	36.23	339	37.46
	1	18		11.61		12.47
	2	18		11.91		11.84
	3	23		12.12		12.62
WGCTA	T	99	277	71.65	219	67.49
	1	20		11.69		10.04
	2	16		12.88		11.68
	3	25		19.78		18.52
	4	24		16.54		17.24
	5	14		10.76		10.01
SILANCE	1	17	443	5.51	276	6.05
	2	17		5.76		6.41
	3	17		5.78		6.12
SPOTS	T				276	119.63
DS	T	40	443	136.91		
CPI	1	22	290	12.40	CPI was administered only at the beginning of the academic year.	
	2	32		19.10		
	3	52		36.99		
	4	32		19.91		
	5	32		19.29		
	6	56		37.68		
	7	38		24.93		
	8	34		22.53		
	9	39		25.62		

APPENDIX E

MEDIAN SCORE OF INSTRUMENTS USED IN STUDY

TABLE 56

MEDIAN SCORE OF INSTRUMENTS USED IN STUDY

			PRE		POST	
TEST	SUB. TEST	# ITEM	# STS.	MEDIAN SCORE	# STS.	MEDIAN SCORE
TOUS	T	60	471	36.70	339	38.08
	1	18		11.88		12.82
	2	18		12.04		12.11
	3	23		12.14		12.59
WGCTA	T	99	277	71.63	219	68.55
	1	20		11.79		10.24
	2	16		13.24		12.29
	3	25		20.24		18.72
	4	24		16.39		17.72
	5	14		10.90		10.18
SILANCE	1	17	443	5.64	276	6.35
	2	17		6.02		6.97
	3	17		6.04		6.80
SPOTS	T					121.50
DS	T	40	443	138.69		
CPI	1	22	290	12.55	CPI was administered only at the beginning of the academic year	
	2	32		19.54		
	3	52		37.79		
	4	32		20.18		
	5	32		19.61		
	6	56		38.07		
	7	38		25.09		
	8	34		22.75		
	9	39		25.75		

APPENDIX F

RELIABILITY OF INSTRUMENTS USED IN STUDY*

TABLE 57

RELIABILITY OF INSTRUMENTS USED IN STUDY*

TEST	SUB. TEST	# ITEM	# STS.	PRE RELIAB.	# STS.	POST RELIAB.
TOUS	T	60	471	0.692	339	.707
	1	18		0.480		0.515
	2	18		0.416		0.415
	3	23		0.376		0.371
WGCTA	T	99	277	0.756	219	0.790
	1	20		0.096		0.446
	2	16		0.560		0.622
	3	25		0.649		0.519
	4	24		0.546		0.578
	5	14		0.316		0.454
SILANCE	1		443		276	0.064
	2	17		0.106		0.303
	3	17		0.110		0.378
SPOTS	T					
DS	T					
CPI	1	22	290	0.591	CPI was administered only at the beginning of the academic year	
	2	32		0.665		
	3	52		0.670		
	4	32		0.500		
	5	22		0.470		
	6	56		0.614		
	7	38		0.645		
	8	34		0.516		
	9	39		0.614		

* based on Kuder Richardson formula 21

APPENDIX G

STANDARD DEVIATION OF INSTRUMENTS USED IN STUDY

TABLE 58

STANDARD DEVIATION OF INSTRUMENTS USED IN STUDY

TEST	SUB TEST	# ITEM	# STS. PRE	STAND. DEV.	# STS. POST	STAND. DEV.
TOUS	T	60	471	6.71	339	6.80
	1	18		2.75		2.73
	2	18		2.58		2.58
	3	23		2.99		2.97
WGCTA	T	99	277	8.86	219	10.04
	1	20		2.31		2.95
	2	16		2.30		2.75
	3	25		3.31		3.09
	4	24		3.29		3.30
	5	14		1.88		2.40
SILANCE	1	17	443	1.87	276	2.04
	2	17		2.06		2.36
	3	17		2.06		2.46
SPOTS	T				276	20.36
DS	T	40	443	25.48		
CPI	1	22	290	3.52	CPI was administered only at the beginning of the academic year	
	2	32		4.65		
	3	52		5.58		
	4	32		3.82		
	5	32		3.75		
	6	56		5.57		
	7	38		4.80		
	8	34		3.90		
	9	39		4.68		

APPENDIX H

MEANS AND STANDARD DEVIATIONS OF THE INDEPENDENT VARIABLES FOR GROWTH IN TOUS SCORES

TABLE 59

MEANS AND STANDARD DEVIATIONS OF THE INDEPENDENT VARIABLES FOR GROWTH IN TOUS SCORES

VARIABLE		MEAN	STD. DEV.
1	High School Rank	86.09	12.25
2	College Physical Sciences	0.55	2.46
3	High School Physical Sciences	1.26	0.72
4	College Math.	3.18	5.27
5	High School Math.	3.23	0.86
6	Science ACT	25.33	4.26
7	Math ACT	26.73	4.70
8	Classification	1.14	0.35
9	Require-Elective	1.25	0.43
10	College Biology	1.87	3.39
11	High School Biology	1.28	0.46
12	English ACT	23.83	3.28
13	Sex	1.63	0.48
14	Dogmatism	136.08	22.71
15	Flexibility	12.32	3.57
16	Tolerance	19.20	4.67
17	Achievement via Independence	20.17	3.78
18	Intellectual Efficiency	37.28	5.62
19	Achievement via Conformity	25.07	4.65
20	Responsibility	26.08	4.39
21	Self Acceptance	22.40	3.92
22	Social Presence	37.40	5.51
23	Capacity for Status	19.25	3.76
24	Instructor #1	0.20	0.40
25	Instructor #2	0.46	0.50
26	Instructor #3	0.33	0.47

APPENDIX I

MEANS AND STANDARD DEVIATIONS OF THE INDEPENDENT VARIABLES FOR GROWTH IN WGCTA SCORES

TABLE 60

MEANS AND STANDARD DEVIATIONS OF THE INDEPENDENT VARIABLES FOR GROWTH IN WGCTA SCORES

VARIABLE		MEAN	STD. DEV.
1	High School Rank	86.72	13.05
2	College Physical Sciences	0.58	2.84
3	High School Physical Sciences	1.33	0.69
4	College Math.	2.98	5.95
5	High School Math.	3.19	0.93
6	Science ACT	25.75	3.67
7	Math ACT	27.46	3.88
8	Classification	1.13	0.34
9	Required-Elective	1.30	0.46
10	College Biology	1.67	2.97
11	High School Biology	1.22	0.49
12	English ACT	24.10	2.99
13	Sex	1.70	0.46
14	Dogmatism	138.31	22.92
15	Flexibility	12.65	3.36
16	Tolerance	19.72	4.51
17	Achievement via Independence	20.13	3.31
18	Intellectual Efficiency	37.51	5.25
19	Achievement via Conformity	25.74	4.45
20	Responsibility	26.62	4.41
21	Self Acceptance	22.33	4.43
22	Social Presence	37.75	5.45
23	Capacity for Status	19.76	3.84
24	Instructor #1	0.17	0.38
25	Instructor #2	0.45	0.50
26	Instructor #3	0.38	0.49

APPENDIX J

MEANS AND STANDARD DEVIATIONS OF THE INDEPENDENT VARIABLES FOR GROWTH SCORES ON *SILANCE*

TABLE 61

MEANS AND STANDARD DEVIATIONS OF THE INDEPENDENT VARIABLES FOR GROWTH SCORES ON *SILANCE*

VARIABLE	MEAN	STD. DEV.
1 High School Rank	85.06	13.63
2 College Physical Sciences	0.52	2.62
3 High School Physical Sciences	1.27	0.72
4 College Math.	3.24	5.41
5 High School Math	3.27	0.82
6 Science ACT	25.43	4.17
7 Math ACT	26.92	4.63
8 Classification	1.14	0.35
9 Required-Elective	1.27	0.44
10 College Biology	1.88	3.36
11 High School Biology	1.23	0.43
12 English ACT	23.75	3.04
13 Sex	1.64	0.48
14 Dogmatism	136.30	22.71
15 Flexibility	12.59	3.50
16 Tolerance	19.34	4.70
17 Achievement via Independence	20.30	3.51
18 Intellectual Efficiency	37.33	5.41
19 Achievement via Conformity	25.25	4.52
20 Responsibility	25.98	4.54
21 Self Acceptance	22.23	3.89
22 Social Presence	37.58	5.36
23 Capacity for Status	19.43	3.67
24 Instructor #1	0.16	0.37
25 Instructor #2	0.46	0.50
26 Instructor #3	0.38	0.49

APPENDIX K

MEANS AND STANDARD DEVIATIONS OF THE INDEPENDENT VARIABLES FOR GROWTH SCORES ON SPOTS

TABLE 62

MEANS AND STANDARD DEVIATIONS OF THE INDEPENDENT VARIABLES FOR GROWTH SCORES ON SPOTS

VARIABLE		MEAN	STD. DEV.
1	High School Rank	84.31	14.24
2	College Physical Sciences	0.59	2.63
3	High School Physical Sciences	1.29	0.74
4	College Math.	3.42	5.41
5	High School Math	3.30	0.84
6	Science ACT	25.49	4.16
7	Math ACT	26.91	4.58
8	Classification	1.15	0.35
9	Required-Elective	1.27	0.44
10	College Biology	1.99	3.43
11	High School Biology	1.22	0.43
12	English ACT	23.67	2.95
13	Sex	1.61	0.49
14	Dogmatism	137.56	22.73
15	Flexibility	12.34	3.59
16	Tolerance	19.16	4.74
17	Achievement via Independence	19.98	3.61
18	Intellectual Efficiency	37.15	5.36
19	Achievement via Conformity	25.15	4.58
20	Responsibility	25.88	4.43
21	Social Acceptance	22.31	4.01
22	Social Presence	37.37	5.53
23	Capacity for Status	19.27	3.76
24	Instructor #1	0.15	0.35
25	Instructor #2	0.47	0.50
26	Instructor #3	0.38	0.49

APPENDIX L

MEANS OF INDEPENDENT VARIABLES FOR TOTAL SAMPLE AND FOR EACH INSTRUCTOR

TABLE 63

MEANS OF INDEPENDENT VARIABLES FOR TOTAL SAMPLE AND FOR EACH INSTRUCTOR

VARIABLE	Inst. #1	Inst. #2	Inst. #3	TOTAL SAMPLE
1. ACT Science Score	25.2	25.6	25.0	25.3
2. ACT Math Score	26.8	27.2	26.0	26.7
3. ACT English Score	23.7	23.8	23.9	23.8
4. High school physics	1.3	1.3	1.2	1.3
5. High school math	3.3	3.3	3.1	3.2
6. High school biology	1.3	1.3	1.3	1.3
7. Classification	1.1	1.1	1.1	1.1
8. Required-Elective	1.3	1.2	1.3	1.3
9. Sex	1.7	1.6	1.6	1.6
10. Flexibility	11.8	12.7	12.1	12.3
11. Dogmatism	133.5	135.3	138.2	136.0
12. Responsibility	26.3	26.0	26.0	26.1
13. Ach. Via Indep.	20.5	20.3	19.8	20.2
14. Self Acceptance	22.0	22.5	22.6	22.4
15. Capacity for Status	19.5	19.5	19.0	19.3
16. College Math	3.9	3.5	2.2	3.2
17. College biology	2.2	1.9	1.6	1.9
18. Tolerance	20.0	19.5	18.4	19.2
19. Intellectual efficiency	37.6	37.5	36.9	37.3
20. Ach. Via Conf.	24.9	25.1	25.0	20.2
21. Social presence	38.0	37.8	36.5	37.4
22. College Physics	.44	.84	.20	.54
23. High School Rank	88.5	86.3	83.7	86.1

APPENDIX M

STUDENT PERCEPTION OF TEACHER STYLE (SPOTS)

Direction: Each of the following 17 statements describes a facet of physical science classroom behavior. Please rate the intensity or frequency of specific teacher behaviors on 9 point rating scales on the answer sheet.

1. The physical science teacher is mainly interested in

1 2 3	4 5 6	7 8 9
How many facts you know	If they get an idea across to you	Whether you can "think" for yourself

2. The physical science teachers

1 2 3	4 5 6	7 8 9
Make you do what they want you to most of the time	Make you do what they want you to sometimes	Let you make your own decisions most of the time

3. The physical science teachers

1 2 3	4 5 6	7 8 9
Don't like to talk about any subject that is not a part of your course	Talk about your course subject a lot but encourage the discussion of other matters	Like to talk about different subjects and are interested in your personal opinions

4. The students in our physical science classes

1 2 3	4 5 6	7 8 9
Only speak when the teachers ask them a question	Feel free to ask the teachers questions	Feel free to speak up at almost any time

5. When the teachers or another student says something you don't agree with

1 2 3	4 5 6	7 8 9
You try not to start an argument and feel that it's not your job to tell him he's wrong.	You tell why you disagree when the teachers ask you to	You feel free to discuss and argue your point of view whether the teachers ask you or not

6. The physical science teachers

1 2 3	4 5 6	7 8 9
Usually base their opinions on what the book says or what the administration says	Usually give you another point of view in addition to what the book says	Tell you that books, teachers, administration and customs are not always right

7. If you were to call your physical science teachers by their first names

1 2 3	4 5 6	7 8 9
They wouldn't like it and would tell you not to do it	They would tell you that it's alright to call them by their first name outside of school but would prefer you call them by their last name while they are teaching	They wouldn't mind at all

8. The physical science teachers

1 2 3	4 5 6	7 8 9
Never tell jokes while they are teaching and do not like it when students joke around	Sometimes tell a joke or a humorous story to get a point across	Always tell funny stories and encourage the students to tell about funny things that have happened to them

9. The physical science teachers spend a lot of time

1 2 3	4 5 6	7 8 9
Telling you about test grades and about how the course is planned	Giving you an idea about tests, grades and the course but not the details.	Asking you to make your own decisions about tests, grades, the course plan

10. When we are working on a group project or in a committee, the physical science teachers

1 2 3	4 5 6	7 8 9
Tell us exactly what to do	Suggest ways that the project might be handled	Let the group members decide how the project should be handled

11. The physical science teachers usually

1 2 3	4 5 6	7 8 9
Make all the students do the same thing in class (working, studying)	Make some students work on projects and some students study, depending on how far behind they are	Let the students do what they like as long as they complete the number of projects or chapters assigned by the end of the week

12. When you get angry at the physical science teachers

1 2 3	4 5 6	7 8 9
You usually hold it in because the teachers would punish any show of anger	You feel that you can tell the teachers why you are angry	You feel that you could show your anger without the teacher becoming angry

13. The physical science teachers

1 2 3	4 5 6	7 8 9
Act like teachers all the time	Act like teachers most of the time but sometimes seem more like friends	Act like friends more than they act like teachers

14. The first thing the physical science teachers do when they come into the room

1 2 3	4 5 6	7 8 9
Is to tell you to be quiet so that they can take attendance	Is to take attendance and ask you why some students are absent (if they are sick, etc.)	Is to let you start your projects or studying and then take attendance while you're working

15. In the physical science classes homework

1 2 3	4 5 6	7 8 9
Is assigned every day and must be handed in the next day	Is divided between work which is due every day and a few long term projects each term	Usually consists of long-term projects

16. In our class students work together in a group or on a committee

1 2 3	4 5 6	7 8 9
Never	Sometimes	A great deal

17. When there is work which has to be done with another student we are

1 2 3	4 5 6	7 8 9
Usually told with whom to work	Can sometimes choose our own work partner	Can usually decide with whom we want to work

APPENDIX N

CORRELATION MATRIX FOR ALL VARIABLES IN STEPWISE REGRESSION FOR *TOUS*

TABLE 64

CORRELATION MATRIX FOR ALL VARIABLES IN STEPWISE REGRESSION FOR *TOUS*

VAR.	1	2	3	4	5	6	7	8	9
1	1.00	.02	.09	-.09	-.04	.15	.30	-.25	-.04
2		1.00	.25	.47	.07	-.001	-.03	.35	.20
3			1.00	.41	.40	.26	.30	.01	.22
4				1.00	.41	.18	.24	.25	.44
5					1.00	.20	.44	-.07	.28
6						1.00	.54	-.15	.10
7							1.00	-.20	.12
8								1.00	.07
9									1.00

TABLE 64 (CONT'D.)

VAR.	10	11	12	13	14	15	16	17	18
1	-.02	.08	.40	.31	-.03	-.11	.03	.05	.06
2	.22	-.03	-.07	-.14	.11	-.21	-.10	-.11	-.08
3	-.01	.06	-.04	-.33	.06	-.05	-.15	-.15	-.10
4	-.02	-.04	-.20	-.39	.11	-.23	-.16	-.21	-.12
5	-.04	.10	-.04	-.33	.10	-.12	-.19	-.27	-.23
6	-.21	-.04	.36	-.20	-.07	.11	.06	.13	.14
7	-.12	.02	.39	-.07	.01	-.02	-.03	-.08	-.02
8	.41	-.09	-.11	-.17	-.00	.04	.05	.04	.08
9	.03	.04	-.10	-.30	.10	-.13	-.09	-.14	-.05
10	1.00	.02	.08	.11	-.03	.02	.07	.07	.05
11		1.00	-.06	.03	-.08	-.07	.02	-.09	-.04
12			1.00	.40	-.16	.22	.13	.33	.20
13				1.00	-.14	.13	.27	.32	.21
14					1.00	-.23	-.42	-.47	-.37
15						1.00	.36	.58	.40
16							1.00	.65	.69
17								1.00	.64
18									1.00

TABLE 64 (CONT'D.)

VAR.	19	20	21	22	23	24	25	26	27
1	.19	.16	.16	-.04	.08	.12	.10	.02	-.10
2	-.05	-.13	.13	-.03	-.02	-.03	-.02	.11	-.10
3	-.07	-.10	.08	-.05	-.05	-.03	.01	.05	-.06
4	-.13	-.12	.10	.02	-.12	-.10	.07	.06	-.13
5	-.21	-.22	-.05	-.02	-.17	-.13	.06	.06	-.11
6	.02	.11	.12	.10	.15	.00	-.01	.06	-.05
7	-.01	.06	.01	.02	.06	-.01	.01	.10	-.11
8	-.03	-.13	-.06	-.02	.01	-.12	-.02	-.03	.05
9	-.12	-.02	.12	.01	-.10	-.01	.05	-.07	.03
10	.05	.02	.03	-.03	.01	-.01	.04	.02	-.06
11	.03	-.05	.04	.08	.01	.01	.06	-.03	-.01
12	.15	.22	.04	.04	.21	.11	-.02	-.01	.03
13	.25	.28	.06	.07	.20	.16	.08	-.07	.00
14	-.23	-.23	-.06	-.16	-.25	-.03	-.06	-.03	.08
15	-.01	.02	-.03	.24	.27	.04	-.07	.11	-.05
16	.53	.55	.13	.37	.47	.07	.09	.06	-.13
17	.40	.42	.11	.25	.41	.14	.05	.03	-.07
18	.56	.49	.34	.52	.64	.15	.03	.04	-.06
19	1.00	.65	.25	.23	.47	.13	-.01	.01	-.01
20		1.00	.09	.05	.36	.15	.03	-.02	-.001
21			1.00	.60	.46	.07	-.06	.03	.02
22				1.00	.64	.07	.06	.07	-.12
23					1.00	.06	.03	.05	-.08
24						1.00	-.18	-.05	.21
25							1.00	-.47	-.36
26								1.00	-.66
27									1.00

APPENDIX O

CORRELATION MATRIX FOR ALL VARIABLES IN STEPWISE REGRESSION FOR WGCTA

TABLE 65

CORRELATION MATRIX FOR ALL VARIABLES IN STEPWISE REGRESSION FOR WGCTA

VAR.	1	2	3	4	5	6	7	8	9
1	1.00	.11	-.07	-.03	-.17	.16	.22	-.10	-.07
2		1.00	.37	.64	.12	.01	.08	.26	.24
3			1.00	.45	.37	.22	.24	.06	.24
4				1.00	.39	.22	.27	.31	.46
5					1.00	-.03	.27	-.05	.27
6						1.00	.43	-.04	.09
7							1.00	-.13	.07
8								1.00	.05
									1.00

TABLE 65 (CONT'D.)

VAR.	10	11	12	13	14	15	16	17	18
1	.06	-.05	.37	.33	.03	-.14	.04	.11	.11
2	.01	.04	.08	-.13	.15	-.20	-.21	-.12	-.12
3	-.06	.18	-.12	-.33	.00	.02	-.22	-.08	-.15
4	.04	-.04	-.14	-.28	.08	-.14	-.16	-.12	-.14
5	.07	.17	-.25	-.28	.04	-.02	-.14	-.23	-.22
6	-.09	-.03	.24	-.15	-.14	.06	-.002	.15	.08
7	.03	-.06	.24	-.10	-.02	-.03	-.09	-.09	.00
8	.35	-.06	-.02	-.12	.04	.06	.13	.10	.13
9	-.03	-.01	-.07	-.36	.08	-.05	-.13	-.08	-.07
10	1.00	.17	.14	.14	-.04	.05	.25	.23	.24
11		1.00	-.06	.05	-.05	-.05	-.001	.06	.02
12			1.00	.34	-.04	.16	.08	.24	.16
13				1.00	-.04	-.06	.22	.27	.23
14					1.00	-.30	-.48	-.45	-.35
15						1.00	.30	.52	.31
16							1.00	.63	.67
17								1.00	.66
18									1.00

TABLE 65 (CONT'D.)

VAR.	19	20	21	22	23	24	25	26	27
1	.23	.21	.23	-.04	.13	.11	.05	.09	-.13
2	-.01	-.10	.14	.01	-.05	.18	-.01	.15	-.15
3	-.09	-.14	.01	-.09	-.20	.03	.06	.10	-.15
4	-.06	-.13	.09	.00	-.16	.14	.06	.20	-.25
5	-.18	-.23	-.08	-.003	-.28	-.10	.03	.04	-.06
6	-.03	.03	.15	-.05	-.01	.02	-.01	.10	-.10
7	-.02	.06	.04	.01	-.07	-.12	-.16	.18	-.06
8	.08	-.13	.03	.05	.05	-.01	-.18	.04	.10
9	-.10	-.04	.17	.07	-.07	.07	.04	-.08	.05
10	.16	.17	.05	.09	.09	.02	.05	.01	-.05
11	.12	-.04	.01	.16	.06	-.00	.08	-.01	-.06
12	.07	.14	.17	.04	.22	-.01	-.02	-.07	.08
13	.28	.32	.12	.07	.24	-.00	.29	-.17	-.05
14	-.18	-.26	-.05	-.16	-.21	.14	-.02	-.01	.02
15	-.10	-.09	-.10	.13	.15	-.09	-.13	.13	-.03
16	.40	.44	.16	.39	.40	-.16	.01	.12	-.13
17	.36	.36	.11	.23	.33	-.11	.07	.10	-.16
18	.57	.38	.34	.50	.61	-.11	-.04	.16	-.13
19	1.00	.59	.29	.31	.51	.02	-.05	.08	-.04
20		1.00	.01	-.04	.19	.07	.09	.07	-.14
21			1.00	.62	.48	.00	-.09	.10	-.04
22				1.00	.65	-.06	-.02	.09	-.08
23					1.00	-.07	-.09	.09	.00
24						1.00	.16	.02	-.15
25							1.00	-.41	-.36
26								1.00	-.71
27									1.00

APPENDIX P

CORRELATION MATRIX FOR ALL VARIABLES IN STEPWISE REGRESSION FOR SILANCE

TABLE 66

CORRELATION MATRIX FOR ALL VARIABLES IN STEPWISE REGRESSION FOR SILANCE

VAR.	1	2	3	4	5	6	7	8	9
1	1.00	.09	.09	-.003	-.06	.12	.26	-.15	-.05
2		1.00	.30	.49	.11	.05	.03	.31	.24
3			1.00	.39	.33	.28	.33	.03	.23
4				1.00	.44	.18	.31	.27	.48
5					1.00	.17	.44	-.05	.33
6						1.00	.55	-.05	.14
7							1.00	-.14	.19
8								1.00	.02
9									1.00

TABLE 66 (CONT'D.)

VAR.	10	11	12	13	14	15	16	17	18
1	.01	.03	.27	.32	.07	-.13	.04	.08	.06
2	.20	-.01	.03	-.12	.11	-.21	-.09	-.07	-.03
3	-.02	.10	-.06	-.30	.07	-.06	-.14	-.10	-.11
4	-.02	.01	-.19	-.32	.09	-.22	-.12	-.15	-.06
5	-.003	.13	-.16	-.33	.16	-.16	-.15	-.25	-.19
6	-.22	-.04	.32	-.28	-.07	.11	.08	.14	.13
7	-.18	.05	.20	-.17	.09	-.07	-.06	-.10	-.02
8	.41	-.12	-.02	-.05	.04	.07	.13	.15	.17
9	-.03	.13	-.09	-.33	.05	-.16	-.07	-.15	-.03
10	1.00	-.03	.07	.18	.01	.07	.20	.18	.13
11		1.00	-.11	.01	-.03	-.09	-.02	-.10	-.03
12			1.00	.37	-.10	.23	.14	.33	.15
13				1.00	-.08	.08	.23	.24	.14
14					1.00	-.24	-.43	-.45	-.38
15						1.00	.37	.54	.38
16							1.00	.63	.69
17								1.00	.66
18									1.00

TABLE 66 (CONT'D.)

VAR.	19	20	21	22	23	24	25	26	27
1	.24	.20	.14	-.07	.08	-.03	.08	.06	-.12
2	-.02	-.09	.18	.02	.01	-.07	-.001	.13	-.14
3	-.09	-.05	.08	-.04	-.05	.08	-.05	.13	-.09
4	-.08	-.06	.11	.02	-.11	.05	.02	.17	-.19
5	-.16	-.14	.01	-.04	-.17	-.02	.07	.09	-.15
6	.00	.08	.22	.12	.14	.01	-.07	.09	-.04
7	.04	.12	.02	-.06	.01	-.01	-.04	.17	-.14
8	.11	-.05	.02	.07	.11	.00	-.09	.10	-.04
9	-.11	.01	.15	-.01	-.09	.18	.07	-.07	.03
10	.16	.14	.01	.00	.09	-.07	.03	.05	-.07
11	.02	-.04	.06	.05	-.01	.03	.08	-.02	-.05
12	.14	.22	.08	.00	.18	-.06	-.02	-.07	.08
13	.22	.26	.02	.01	.18	-.09	.13	-.19	.10
14	-.20	-.23	-.15	-.22	-.27	.04	-.06	.03	.01
15	-.06	-.01	-.03	.23	.22	.07	-.11	.08	-.002
16	.50	.49	.13	.37	.48	-.03	.07	.05	-.10
17	.40	.42	.14	.25	.39	.00	.03	.04	-.06
18	.51	.44	.33	.51	.62	.05	.07	.05	-.11
19	1.00	.63	.18	.18	.43	-.04	.11	-.03	-.05
20		1.00	-.02	-.06	.26	.06	.06	.02	-.07
21			1.00	.56	.50	.05	-.02	.03	-.02
22				1.00	.60	.01	.06	.04	-.08
23					1.00	.03	.01	.04	-.05
24						1.00	-.15	.04	.07
25							1.00	-.40	-.34
26								1.00	-.72
27									1.00

APPENDIX Q

CORRELATION MATRIX FOR ALL VARIABLES IN STEPWISE REGRESSION FOR SPOTS

TABLE 67

CORRELATION MATRIX FOR ALL VARIABLES IN STEPWISE REGRESSION FOR SPOTS

VAR.	1	2	3	4	5	6	7	8	9
1	1.00	.05	.07	.02	-.07	.10	.26	-.10	-.002
2		1.00	.30	.48	.12	.08	.03	.29	.22
3			1.00	.41	.40	.27	.31	.04	.21
4				1.00	.45	.18	.31	.25	.42
5					1.00	.16	.38	-.05	.32
6						1.00	.55	-.06	.08
7							1.00	-.14	.16
8								1.00	.05
9									1.00

TABLE 67 (CONT'D.)

VAR.	10	11	12	13	14	15	16	17	18
1	.03	.03	.26	.28	.06	-.11	-.01	.03	.01
2	.19	-.01	.03	-.14	.11	-.18	-.07	-.04	-.03
3	.00	.12	-.08	-.34	.09	-.09	-.15	-.16	-.11
4	-.03	.02	-.20	-.33	.09	-.22	-.13	-.19	-.07
5	-.02	.19	-.18	-.37	.12	-.12	-.12	-.22	-.17
6	-.18	.04	.31	-.30	.03	.09	.08	.10	.11
7	-.16	.01	.19	-.16	.10	-.09	-.04	-.08	-.01
8	.43	-.10	.00	-.04	.02	.13	.12	.16	.16
9	.01	.14	-.10	-.30	.04	-.14	-.08	-.15	.01
10	1.00	-.03	.13	.16	-.01	.15	.18	.21	.12
11		1.00	-.17	-.03	-.06	-.09	-.04	-.11	-.07
12			1.00	.34	-.07	.19	.12	.26	.13
13				1.00	-.08	.07	.22	.23	.12
14					1.00	-.26	-.39	-.41	-.37
15						1.00	.37	.57	.38
16							1.00	.64	.69
17								1.00	.62
18									1.00

TABLE 67 (CONT'D.)

VAR.	19	20	21	22	23	24	25	26	27
1	.12	.21	.13	-.10	.02	-.07	.06	.12	-.16
2	-.01	-.10	.18	.04	.04	.09	-.004	.12	-.12
3	-.07	-.05	.07	-.07	-.09	-.06	-.05	.11	-.08
4	-.09	-.07	.08	.02	-.11	-.01	.02	.15	-.17
5	-.17	-.17	-.01	-.02	-.15	-.03	.05	.13	-.16
6	-.01	.09	.19	.07	.12	-.03	-.06	.03	.01
7	.03	.14	.01	-.06	.01	-.07	-.03	.16	-.14
8	.07	-.07	.02	.09	.12	.06	-.08	.11	-.05
9	-.08	.01	.16	.03	-.05	-.03	.05	-.07	.04
10	.11	.09	.02	.03	.10	.04	.04	.05	-.08
11	-.01	-.08	.05	.07	-.02	-.13	.07	.01	-.07
12	.14	.25	.07	-.02	.16	.05	-.03	-.06	.08
13	.17	.25	.01	-.004	.12	.11	.13	-.13	.04
14	-.14	-.19	-.08	-.21	-.24	.13	-.08	.02	.03
15	-.08	-.04	-.03	.25	.23	.08	-.08	.07	-.02
16	.45	.46	.13	.40	.49	-.001	.03	.08	-.10
17	.34	.34	.08	.24	.36	.04	.02	.04	-.06
18	.51	.43	.33	.52	.62	-.03	.05	.10	-.14
19	1.00	.61	.19	.19	.44	.02	.01	-.01	.00
20		1.00	-.02	-.05	.25	-.02	.03	.03	-.05
21			1.00	.59	.49	.05	-.02	.06	-.05
22				1.00	.63	.02	.02	.08	-.10
23					1.00	-.08	-.04	.08	-.06
24						1.00	-.23	-.13	.30
25							1.00	-.39	-.33
26								1.00	-.74
27									1.00